SAE Journal

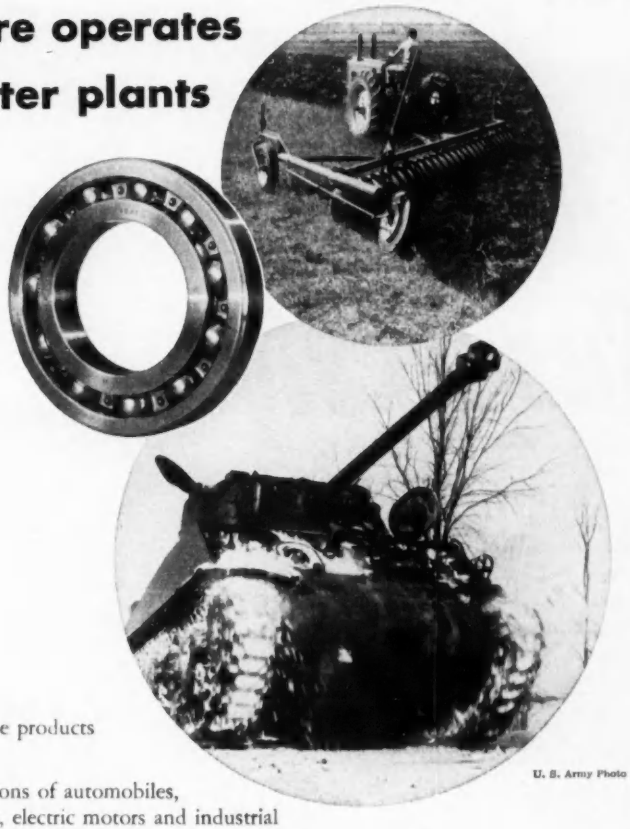
APRIL 1952

PUBLISHED BY THE SOCIETY OF AUTOMOTIVE ENGINEERS

Have you heard?... 21 of 25
leading engine manufacturers using chrome rings
specify Perfect Circle
The Standard of Comparison

The application of solid chrome plating to piston rings, as perfected by Perfect Circle, more than doubles the life of pistons, rings and cylinders. Performance data will be furnished on request. Write Perfect Circle Corporation, Hagerstown 3, Indiana.

New Departure operates guns-and-butter plants



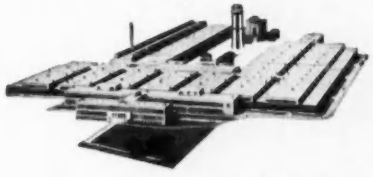
U. S. Army Photo

Ball bearings are essential to the products of our industrial might.

The ball bearings that serve millions of automobiles, trucks, tractors, farm implements, electric motors and industrial machinery are of the same materials, the same heat treatment, the same methods of precision manufacture as those required for mechanized warfare and electronic instruments. Thus conversion from one to the other at New Departure is largely a matter of changing the emphasis on types and sizes.

The productive capacities of the world's largest ball bearing factories are your assurance of the best possible production of your requirements.

New Departure's engineers and vast resources for research are freely at your disposal.



New Departure's plant at Sandusky, Ohio, where ball bearings are produced for *both* industry and the Armed Forces.

NEW DEPARTURE

Nothing Rolls Like a Ball... **BALL BEARINGS**

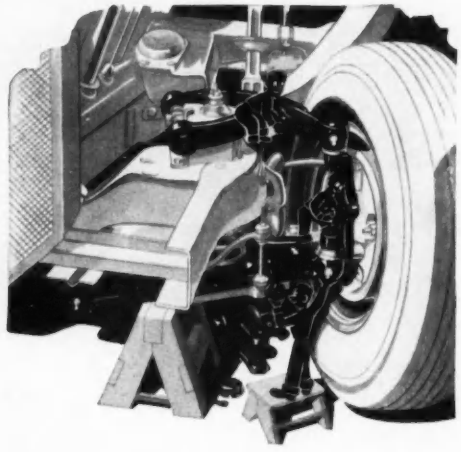
164

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT

For assembly-line or service-jack speed...

You can count on Thompson

Ball Joint Suspension

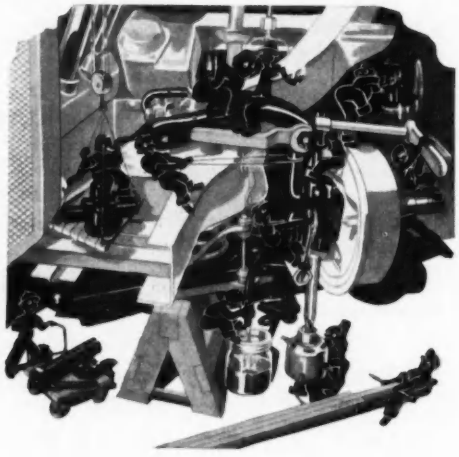


Only three simple operations are required to assemble or remove the compact service package from the suspension. Normal realignment of wheels is unnecessary.

THOMPSON'S new Ball Joint Suspension makes front suspension installation one of the fastest and simplest jobs on the assembly line. Its compact design and parts reduction cuts production from 12 to 3 operations. And the same "stop watch" speed carries over to the service jack. The equivalent of a complete rebushing job can be performed in half an hour.

In addition to high speed in assembly and service, Thompson's Ball Joint Suspension cuts lubrication; eliminates front suspension bind; gives extra under-the-hood space for wider engines. And in road life, steering and handling is easier, service prolonged.

Let the "STEERING ENGINEERS" at Thompson's Detroit Division help you solve your steering problems. Our research, experience and manufacturing facilities are always at the disposal of *all* automobile manufacturers. Call us at WA 1-5010.



Ball Joint Suspension eliminates nine of the operations shown above, including reaming and fitting of the king pin, disassembly of brakes and complete bleeding of the braking system.

Thompson Products, Inc.

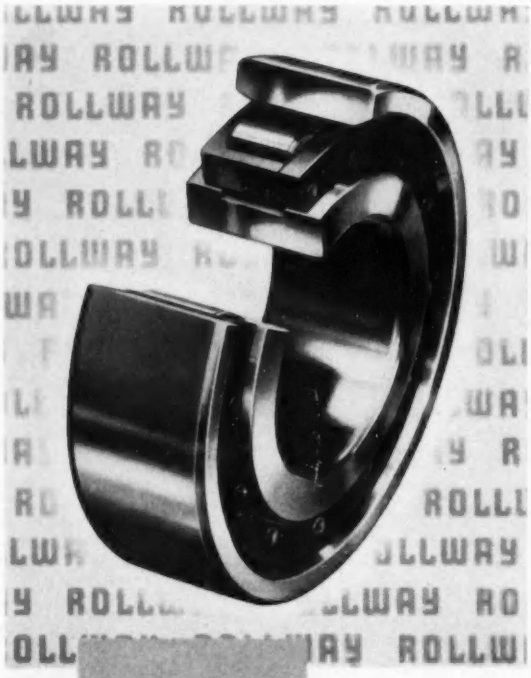
DETROIT DIVISION

7881 Conant Avenue, Detroit, Michigan

SAE JOURNAL, APRIL, 1952, Vol. 60, No. 4. Published monthly by the Society of Automotive Engineers, Inc. Publication office at 10 McGovern Ave., Lancaster, Pa. Editorial and advertising department at the headquarters of the Society, 29 West 39th Street, New York 18, N. Y. $1 per number; $10 per year; foreign $12 per year; to members 50 cents per number, $5 per year. Entered as second class matter, September 15, 1948, at the Post Office at Lancaster, Pa., under the act of August 24, 1912. Acceptance for mailing at special rate of postage provided for in the Act of February 28, 1925, embodied in paragraph (d-2), Sec. 34.40, P. L. and R., of 1948. Additional entry at New York, N. Y.

The Name **Precision** *in "O" Rings is like Sterling on Silver*

Precision Rubber Products
CORPORATION
The "O" Ring Specialists
3110 Oakridge Drive • Dayton 7, Ohio



In-Built Trueness...

basis for longer life and lower cost!

Unwavering right-line rotation . . . that's the immediate result of in-built trueness in Rollway roller bearings. There's no skew, no side-shock, no roller-end-drag. Internal forces are balanced by matchless precision in related parts. Bores are precisely cylindrical. Separator surfaces are rigorously parallel. Roller ends are truly square on every diameter. And bearing surfaces match both the separator slots and the roller races.

Over the long run, life expectancy is greatly extended. Cost per unit of time falls sharply.

RIGHT-ANGLE ROLLER ENDS, precisely square to avoid end-rub, oscillation and side-shock.

RIGHT-ANGLE BEARING SURFACES with parallelism that results in unwavering right-line rolling.

RIGHT-ANGLE SEPARATOR SLOTS accurately machined to prevent roller skew, slide and uneven wear.

Rollways Roll Right Because They're Made Right

Let our engineers help you to select the Rollway bearing that is exactly right for your application. Our years of specialized bearing experience and complete engineering and metallurgical service are always at your command. No cost. No obligation. Just write or wire.

ROLLWAY BEARING CO., INC.
Syracuse 4, N. Y.

SALES OFFICES

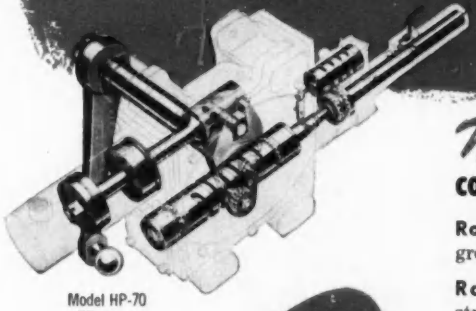
SYRACUSE	DETROIT
PHILADELPHIA	CLEVELAND
BOSTON	LOS ANGELES
PITTSBURGH	HOUSTON

ROLLWAY BEARINGS

Complete Line of Radial and Thrust Cylindrical Roller Bearings

Ross HYDRAULIC POWER STEERING . . . SINCE 1942

Big brown BEAR . . . 9 feet long and weighing more than 1000 pounds —Alert! Responsive! POWERFUL!



Model HP-70 Effortless, Fatigueless Steering

Now . . . EASIER, SAFER STEERING FOR COMMERCIAL VEHICLES AND PASSENGER CARS

Ross Hydrapower instantly prevents loss of control in soft ground, sand, snow, from tire blow-outs or road obstructions.

Ross Hydrapower steered wheels promptly return to straight-ahead driving position after turns.

With Ross Hydrapower there is no lag in the hydraulic response either for power assistance or resisting shocks—consequently no tendency to over control.

Ross pioneering in assisted steering dates back to 1942 when the U. S. Army chose *Ross* to solve its then toughest steering problem—the 50-ton tank retriever.

While most current *Ross Hydrapower* production is devoted to military needs—as government requirements permit, *Ross Hydrapower* will bring new steering *ease, safety* and *satisfaction* to additional commercial vehicles and passenger cars.

HYDRAPOWER Ross

Cam & Lever **STEERING**

ROSS GEAR AND TOOL COMPANY • LAFAYETTE, INDIANA

Rolled bronze bushings, cast bronze bushings

and precision bronze parts, produced in hundreds

of designs, to many alloy specifications and in a great range of sizes.

Use our specialized facilities—capacity now available.

FEDERAL-MOGUL

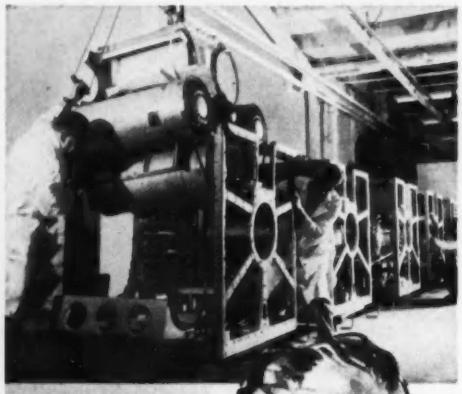
FEDERAL-MOGUL CORPORATION, 11035 SHOEMAKER, DETROIT 13, MICHIGAN

FEDERAL Mogul SINCE 1899

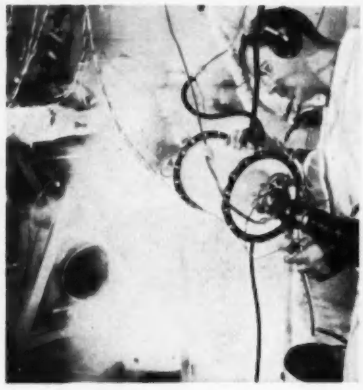
STERLING
PISTONS

Contributing to Better Engine Performance for Over 30 Years

Sterling Engineers will work with you as they have with other leading manufacturers in developing pistons to meet your exacting requirements. Write or phone.



MANUFACTURING
Among the more than 700 products manufactured at AiResearch is a portable gas turbine ground heater. Most powerful heater for its size ever developed, it was designed to heat up Air Force planes and equipment in the Arctic. One unit produces 4,000,000 btu's per hour at −65 degrees F.



Ability of AiRese

...in the design and man

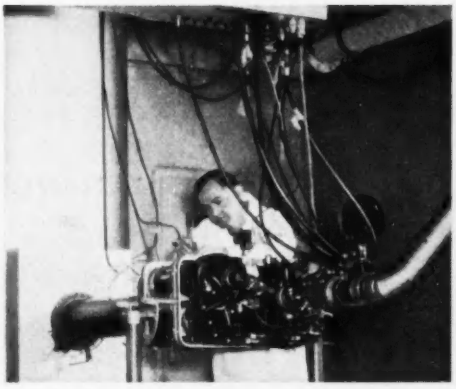
DESIGNER

Would you like to work with us? *Qualified engineers, scientists and skilled craftsmen are needed now at AiResearch. Write for details on a better job with this progressive firm. Address your letter to: AiResearch Manufacturing Co., Los Angeles 45, California.*

Air Turbine Refrigeration

Gas Turbines

RESEARCH *Long range research policies have made the AiResearch Manufacturing Company a recognized industrial leader in many fields. Current lab facilities include 12 major research divisions, equipped to perform countless tests. Pictured at left under test is a moisture control unit for cabin air conditioning.*



QUALITY *Complete production testing facilities, combined with years of experience in proving equipment before delivery, have built the AiResearch reputation for quality. Shown here is a small gas turbine engine in the 100 hp class, one of the many "firsts" pioneered by AiResearch engineers and craftsmen.*

arch to achieve "the impossible"

ufacture of specialized aircraft accessories has made this company a world leader!

Twin targets at AiResearch, since this company entered business in 1939, have been how to make possible: (1) flight at *higher altitude;* (2) flight at *higher speed.*

This has meant design, testing and manufacturing in unexplored fields. The major effort has been to control and utilize patterns of air flow, air density, air pressure and air temperature as they affect high altitude, high speed flight.

The company now employs more than 4500 engineers, technicians and skilled craftsmen in modern plants in Los Angeles and Phoenix. These plants are equipped with complete up-to-date manufacturing facilities. In them are being produced over 700 different accessory products. All were developed and proven in the company's research laboratories, the most complete of their kind in existence.

Today every type of high speed, high altitude airplane of U. S. design is equipped with AiResearch products. Only AiResearch can supply all the integrated system components for cabin pressurization and air conditioning and lightweight pneumatic power for aircraft.

TODAY *AiResearch concentrates on helping to make America's commercial transports and military fighting planes the best in the world.*

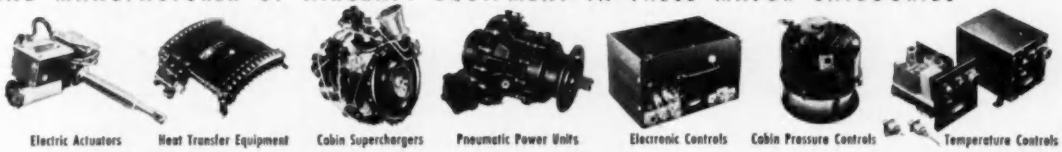
TOMORROW *this proven ability will be available to meet new problems in the advance of aeronautics and in other fields of industrial enterprise.*

AiResearch Manufacturing Company

A DIVISION OF THE GARRETT CORPORATION

LOS ANGELES 45, CALIFORNIA

AND MANUFACTURER OF AIRCRAFT EQUIPMENT IN THESE MAJOR CATEGORIES



Electric Actuators · Heat Transfer Equipment · Cabin Superchargers · Pneumatic Power Units · Electronic Controls · Cabin Pressure Controls · Temperature Controls

Mighty muscles to wrestle kegs

but not for steering

Horse Power Did The Steering
Then... *Why not now!*

Majestic brewery horses, as they nodded their gay plumes and jingled the shining brass-mounted harness, supplied horsepower for steering. The driver merely guided them with easy wrist motions. He had mighty muscles—for wrestling kegs—not for fighting a steering wheel. • The ordinary brewery truck or other truck of today has lost its horsepower for steering. Everything is made easy for the driver except the job he has to do at every corner he turns . . . when dodging traffic . . . in parking. He herds the hack by main strength, often parks with wrenching heaves. If the vehicle is very big he has to have mighty muscles, no matter what he's carrying. • And he tires on the job . . . he slows down, becomes less efficient and gets less done. • Why not have Vickers Hydraulic Power Steering on your trucks? It provides the horsepower for steering so the driver can handle any vehicle with an easy twist of the wrist. He retains his efficiency and gets more done . . . with greater safety. Get the details on Vickers Hydraulic Power Steering; write for Bulletin M-5100.

VICKERS Incorporated

DIVISION OF THE SPERRY CORPORATION

1440 OAKMAN BLVD. • DETROIT 32, MICH.

Application Engineering Offices: ATLANTA • CHICAGO (Metropolitan) CINCINNATI • CLEVELAND • DETROIT • HOUSTON • LOS ANGELES (Metropolitan) NEW YORK (Metropolitan) • PHILADELPHIA • PITTSBURGH • ROCHESTER ROCKFORD • ST. LOUIS • SEATTLE • TULSA • WASHINGTON • WORCESTER

VICKERS *hydraulic*
POWER STEERING
is Effortless, Positive and Shockless

4697

BALL bearings are necessarily made to close tolerances which apply not only to the balls and races but also to the retainers which must have exact dimensions and shapes. This matter of retainer quality has been given careful study by the Stephens-Adamson Mfg. Co., Aurora, Illinois, maker of the well-known SealMaster Industrial ball bearing units. The company collaborated closely with the Revere Technical Advisory Service in working out the specifications and forming procedures for its brass retaining rings. As a part of this joint activity, Revere made a full survey of Stephens-Adamson requirements, with the object of standardizing and simplifying specifications for the benefit of both the engineering and the purchasing departments. The success of this work is indicated by this statement from the Superintendent of SealMaster bearing production: "First and foremost, I am pleased with the uniformity of gauge and temper of the Revere brass we have been receiving. This uniformity makes it possible to produce ball retainers of very close tolerance, with a minimum of rejections and at comparatively low unit cost. Furthermore, I have appreciated the dependable delivery service and the cooperation of the Revere organization."

In these times of scarcities, when it is more than ever necessary to reduce waste and save metal, you may wish to take advantage of Revere's skill and know-how in non-ferrous metals. Just get in touch with the nearest Revere Sales Office.

ABOVE, the largest retainer made for a SealMaster industrial ball bearing unit, contrasted with the smallest block and retainer.

BELOW, three of the steps in retainer production: blanked, formed and punched, and assembled part ready to receive the balls.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, N. Y.

• • •

Mills: Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y.— Sales Offices in Principal Cities. Distributors Everywhere

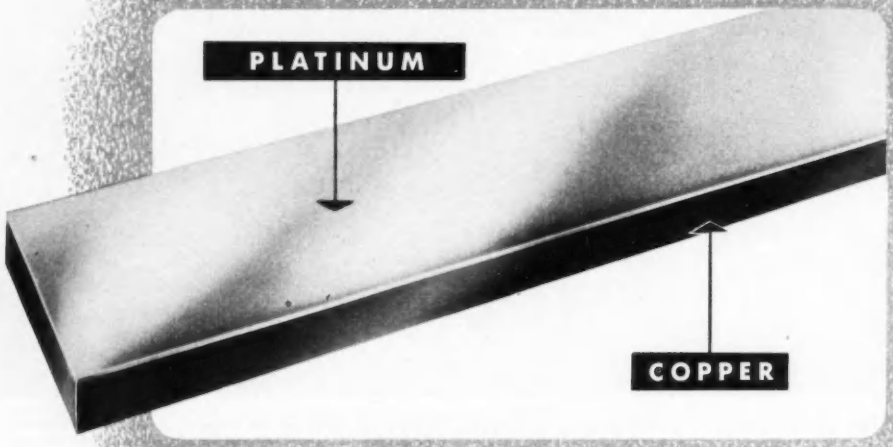
SEE "MEET THE PRESS" ON NBC TELEVISION EVERY SUNDAY

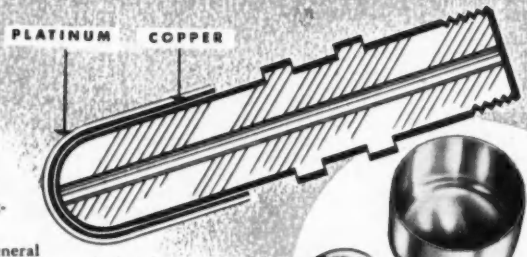
PROBLEM:

How to Reduce the High Cost of Platinum in an Electrode?

GENERAL PLATE

Provided the Solution with Platinum Clad to Copper . . . A Composite Metal





A well-known manufacturer was faced with the problem of how to cut the cost of a platinum electrode. Pure platinum was ideal but was expensive and the supply short.

The problem was presented to General Plate whose engineers quickly found a solution by bonding a thin layer of platinum to a thicker, less costly layer of copper.

The result was a General Plate composite material that gave the performance of pure platinum, and reduced costs considerably.

In addition, General Plate was able to fabricate the complete assembly providing the manufacturer with further savings.

No matter what your problem, it will pay you to consult with General Plate. Their vast experience in cladding precious to base metals, or base to base metals can overcome your problems . . . often reduce costs.

General Plate products include . . . precious metals clad to base metals, base metals clad to base metals, silver solders, composite contacts, buttons and rivets, Truflex® thermostat metals, Alcuplate®, platinum fabrication and refining, #720 manganese age-hardenable-alloy. Write for information.

Have You a Composite Metal Problem? General Plate can solve it for you.

GENERAL PLATE

Division of Metals & Controls Corporation

114 FOREST STREET, ATTLEBORO, MASS.

For the Sake of Argument

Sharing Enthusiasms . . .

By Norman G. Shidle

We all like to share our enthusiasms—but we all find it hard to be the "sharee." We like to have people like what we like; often take a dim view of what excites our associates. It's fun to have folks respond "Say, that's interesting!" to our eagerness; tough to work up a head of steam about theirs.

A search for techniques leading to readier sharing brings more clues than conclusions.

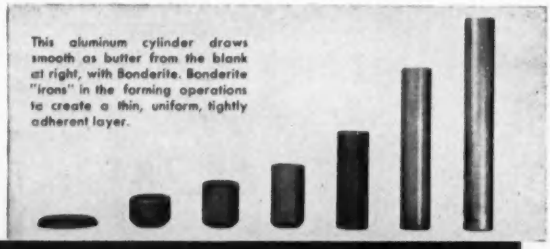
We all have listened to someone explain a process or promote an idea with obvious love and enthusiasm for his subject. One time or another, we all have caught fire from such talk, been roused to make the ideas our own . . . And, at other times, the very pressure of the enthusiasm has made us rebel, aroused our antagonism. The salesman who keeps on promoting his product after he has made the sale is an all too familiar example of the latter.

More often than not, an expressed desire to make others like spinach defeats its own purpose. The more intense our desire to have an enthusiasm shared, the more likely we are to build up pressures which backfire. Ability to get enthusiasms shared is a quality more characteristic of leaders than of salesmen.

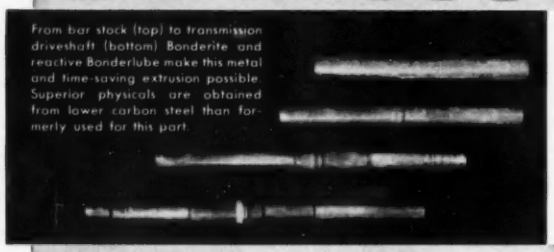
Best results often come when the desire for sharing is not made too apparent. Most of us enthuse more about something we think we discovered than about something we've been urged to like. We enjoy picking up an idea; throw up psychological barriers to attempted injections. (We even heard of an engineer recently who got approval for a pet project—following months of resistance to his enthusiasm for it—by writing a report which brought out all its bad features.)

Awareness of receptivity by a particular listener can help us all to get more "sharees."

This aluminum cylinder draws smooth as butter from the blank at right, with Bonderite. Bonderite "irons" in the forming operations to create a thin, uniform, tightly adherent layer.

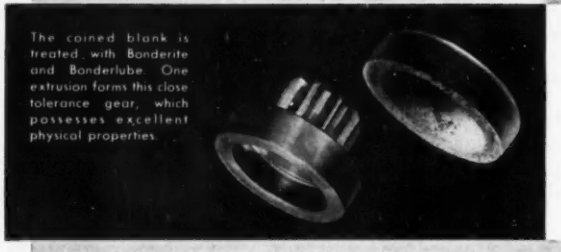


From bar stock (top) to transmission driveshaft (bottom) Bonderite and reactive Bonderlube make this metal and time-saving extrusion possible. Superior physicals are obtained from lower carbon steel than formerly used for this part.

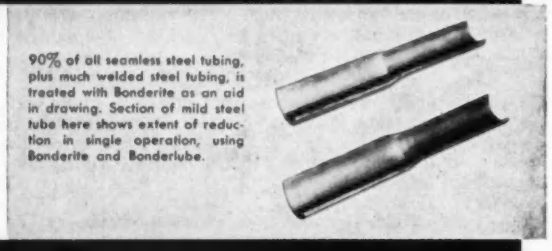


Bonderite and Bonderlube, used in cold drawing of steel 50 caliber cartridge cases, speed production by allowing multiple pass operation and reducing the number of process anneals, and produce a superior product.

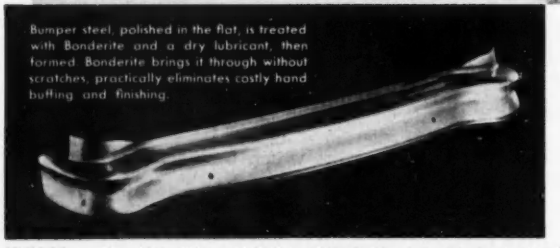
The coined blank is treated with Bonderite and Bonderlube. One extrusion forms this close tolerance gear, which possesses excellent physical properties.



90% of all seamless steel tubing, plus much welded steel tubing, is treated with Bonderite as an aid in drawing. Section of mild steel tube here shows extent of reduction in single operation, using Bonderite and Bonderlube.



Bumper steel, polished in the flat, is treated with Bonderite and a dry lubricant, then formed. Bonderite brings it through without scratches, practically eliminates costly hand buffing and finishing.



Bonderite and Bonderlube

LUBRICATION SYSTEMS FOR METALS SOLVE COLD FORMING PROBLEMS

Eliminate the friction between tools and work, provide proper lubrication between metal and dies, and you can cold form metals with amazing facility.

Bonderite and Bonderlubes provide this effective, positive lubrication for metals in cold forming operations.

With Bonderite and Bonderlubes, benefits are many and varied. Some tube mills (an industry which has used Bonderite in drawing for more than ten years) report over-all production increases of as much as 100%. Other industries report big labor and time savings because of minimum pickling, multiple pass operations, fewer process anneals. Metal savings are large because of extensive elimination of machining. Low alloy steel blanks may frequently be used, with desired physicals attained by the forming operations.

Parker, with more than a decade of experience in this field, offers you trained engineering and operational know-how. Learn how you can get the benefits of Parker's lubrication systems for your cold forming operations. Write today!

Get this FREE BOOKLET! Letterhead request brings informative technical bulletin, "Bonderite as an Aid in Cold Forming." Get your copy NOW!

Parker

PARKER RUST PROOF COMPANY

2181 E. Milwaukee, Detroit 11, Mich.

**Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.*

BONDERITE—corrosion resistant paint base • **BONDERITE and BONDERLUBE**—aids in cold forming of metals • **PARCO COMPOUND**—rust resistant • **PARCO LUBRITE**—wear resistant for friction surfaces

SAE Journal

Norman G. Shidle
Editor

Joseph Gilbert
Managing Editor

SAE JOURNAL PUBLICATION OFFICE
Business Press, Inc.
10 McGovern Ave.
Lancaster, Pa.

EDITORIAL OFFICE
29 West 39th St.
New York 18, N. Y.
Tel.: LOngacre 5-7174

ADVERTISING OFFICES
E. L. Carroll
Eastern Advertising Manager
29 West 39th St.
New York 18, N. Y.
Tel.: LOngacre 5-7170

A. J. Underwood
Western Advertising Manager
3-210 General Motors Bldg.
Detroit 2, Mich.
Tel.: TRinity 2-0606

•

SAE DETROIT OFFICE
808 New Center Bldg.
Tel.: TRinity 5-7495
R. C. Sackett, Staff Representative

SAE WESTERN BRANCH OFFICE
Petroleum Bldg.
714 W. Olympic Blvd.
Los Angeles 15, Calif.
Tel.: Prospect 6559
E. W. Rentz, Jr., West Coast Manager

The Society is not responsible for statements or opinions advanced in papers or discussions at its meetings or in articles in the Journal.

All technical articles appearing in SAE Journal are indexed by Engineering Index, Inc.

Copyrighted 1952, Society of Automotive Engineers, Inc.

TABLE OF CONTENTS

Oil Filtration 17

Air Cleaner-Oil Filter Protection Critical Factor in Engine Wear—W. S. JAMES, B. G. BROWN, and B. E. CLARK 18

Advantages and Limitations of Oil Filters—C. W. GEORGI, J. F. O'CONNELL, and T. C. EITEL 27

New Filtering Problems Created by High Detergency Lubricants—H. M. GADEBUSCH, R. T. KARR, and W. B. BASSETT 33

Factors Affecting Diesel-Engine Starting—JAMES F. BLOSE 40

Squirt Outdoes Flood In Cooling Cutting Tools—R. J. S. PIGOTT and A. T. COLWELL 45

New Horizons for Aero Machining—MALCOLM F. JUDKINS 49

Materials Pinch 52

New SAE Manual Simplifies Computations of Truck Ability 54

Materials Stockpile—MAJOR-GEN. FRANCIS H. GRISWOLD 57

Trends in Gas Turbine Engine Materials—R. H. THIELEMANN, J. C. MERTZ, and W. P. EDDY, JR. 58

Car Steering Gets an Assist—W. K. CRESON 64

Experts Outline Factors in Forging—THOMAS GIALDINI 69

1952 SAE National Passenger Car, Body, and Materials Meeting Reported 71

New Engine Bearing Designs—ALBERT WILLI JR., A. R. SHAW, A. E. ROACH and A. F. UNDERWOOD, and W. E. THILL 80

■

About SAE Members 82

Technical Committee Progress 88

SAE Coming Events 94

25 Years Ago in SAE Journal 95

SAE Section News 96

You'll Be Interested to Know 99

SAE Student News 100

New Members Qualified 129

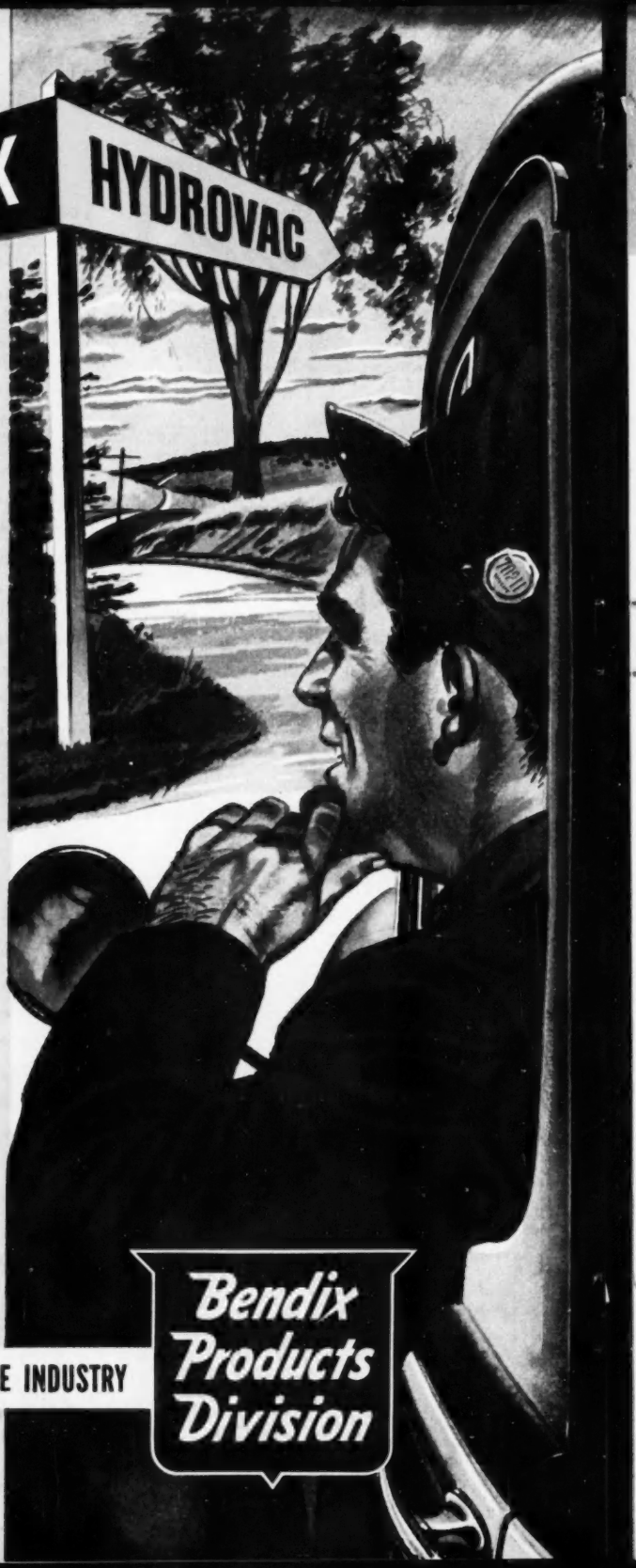
Applications Received 132

Society of Automotive Engineers, Inc.

D. P. Barnard
President

John A. C. Warner
Secretary and Gen. Manager

B. B. Bachman
Treasurer



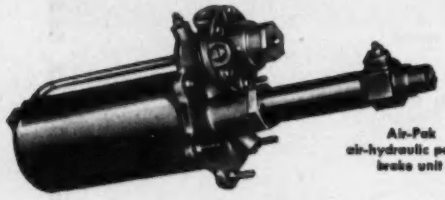
Either Way – YOU'RE ON THE ROAD TO BETTER POWER BRAKING!

There's no need to be puzzled about the question of efficient power braking for *any commercial vehicle*. Where the preference is for a hydraulic system, Hydrovac, with over two and a half million installations, has proven itself the undisputed leader in its field. And for vehicles where air actuated brakes are the choice, the new Bendix Air-Pak air-hydraulic power braking unit is foremost in its field.

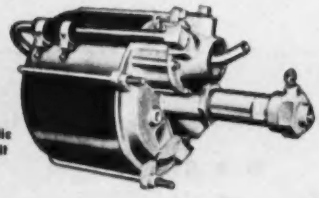
Air-Pak, similar in design and principle to the Hydrovac, changes air pressure into hydraulic pressure by means of two direct connected pistons, thus combining all the well proven advantages of hydraulic brake action with an air brake system.

Products of twenty-five years of practical braking experience, these outstanding power braking systems offer faster, more positive and better controlled braking. And in both the vacuum and the air actuated units, brakes can be applied instantly by foot power alone—a safety factor of tremendous importance. Remember, regardless of size of vehicle or whether your preference is for vacuum or air actuated brakes, for the industry's finest power braking systems—specify Bendix® Hydrovac® or Bendix Air-Pak.

®REG. U. S. PAT. OFF.



Air-Pak
air-hydraulic power
brake unit



Hydrovac
vacuum-hydraulic
power brake unit

BRAKING HEADQUARTERS for the AUTOMOTIVE INDUSTRY

BENDIX · PRODUCTS DIVISION · SOUTH BEND

Export Sales: Bendix International Division, 72 Fifth Ave., New York 11, N.Y. • Canadian Sales: Bendix-Eclipse of Canada, Ltd., Windsor, Ontario, Canada

Bendix AVIATION CORPORATION

Bendix Products Division

Oil Filtration

Many aspects of oil filtration were analyzed at the recent SAE Fuels & Lubricants Meeting held in Chicago, Oct. 30–Nov. 1, 1951.

Authors of three papers—presented at two sessions—described (1) the advantages and limitations of oil filters, (2) filtration problems encountered with high detergency oils, and (3) the importance of good oil filter-air cleaner protection in reducing engine wear.

W. S. James, B. G. Brown, and B. E. Clark, Fram Corp., reported on "Engine Wear from Abrasives in Intake Air." Their paper, in the form of a progress report, showed the importance of good oil filter-air cleaner protection in reducing engine wear.

In fact, these engineers concluded, adequate provision for engine protection by means of both oil filters and air cleaners can give significantly longer engine life with infrequent oil changes than less effective protection and frequent oil changes. An extensive abridgment of this paper appears in this issue on page 18

C. W. Georgi, J. F. O'Connell, and T. C. Eitel, Quaker State Oil Refining Corp., were the authors who noted in their paper, "Oil Filters and Additive Motor Oils," that oil filters have limitations as well as advantages. A lack of understanding of the function and limitations of oil filters, they pointed out, can readily lead to disappointments and loss of the benefits which oil filters can provide.

Such factors in filter performance as solids removal efficiency, sludge holding capacity, oil flow rates, and additive removal from compounded oils, together with filterability of detergent type oils, were thoroughly analyzed by this trio. An extensive abridgment of this paper appears in this issue beginning on page 27

H. M. Gadebusch, Detroit Diesel Engine Division, General Motors Corp.; R. T. Karr, Purolator Products, Inc.; and W. B. Bassett, Lubrizol Corp., reviewed "Oil Filtration Problems with High Detergency Lubricants."

Detergent additives not only effectively counteract the formation of engine deposits by polar suspension of the colloidal contaminants in the oil, they observed, but at the same time render the bulk of the organic contaminating matter unfilterable. Color-clean oil filtration is thus made impossible, introducing the problem of when to change detergent lubricants. An extensive abridgment of this paper appears in this issue beginning on page 33

Air Cleaner-Oil Filter Critical

THIS paper is somewhat in the nature of a progress report on the study of wear in engines and its reduction by the use of air cleaners and oil filters. It is possible, however, to draw these general conclusions:

- Important reductions in engine wear can be accomplished both by the use of adequate air cleaners and by the use of adequate oil filters—a combination of the two giving an exceedingly important increase in engine life.

- Adequate provision for engine protection by means of both oil filters and air cleaners can give very significantly longer engine life with infrequent oil changes than less effective air cleaner-oil filter protection and frequent oil changes.

- To insure properly controlled wear of bores, rings, and bearings, the systems of oil circulation in an engine should receive considerably more study.

Data on engine wear, primarily from abrasive dirt, formed the basis for these conclusions. These data were obtained from (1) tests in a "dust tunnel," (2) paved highway tests in cars, and (3) engine-stand tests with 0 to 5 micron dirt added directly to the oil. The same make and model of 6-cyl engine of conventional L-head design was used throughout. All tests were run at 60 mph—2900 rpm—and with wide open throttle. Water jacket temperatures were maintained at 165 F. The oil temperature was maintained at about 200 F. In some of the later series of tests, an oil temperature control system was used. In all cases, however, comparable oil temperature conditions were used in the comparisons shown.

The paved highway tests were made to establish a basis for judging the magnitude of the wear obtained under dust tunnel conditions in terms of normal road driving. Two cars, using the same engines as used in other tests, were driven 20,000 miles each in normal service over paved highways in Michigan. One of the engines was protected by a conventional oil-wetted air cleaner, but no oil filter, and oil was changed every 1000 miles. This protection has been called "light-duty" protection. The other engine was protected by a very efficient renewable type of air cleaner, and a bypass oil filter of the depth paper type. Oil in this engine was only changed at 10,000 miles when the engine wear was measured. This protection has been called "heavy-duty" protection.

A number of measurements were made before and after each test, but it was found that the most consistent and indicative wear measurements were:

(1) Ring gap increase
(2) Diametral bore wear
(3) Decrease in main and rod bearing weights.

The other measurements taken usually showed the same kind of wear as on rings, bores, and bearings—but not as clearly—and for simplicity are omitted. In some of the early tests, the figures of wear include break-in wear. In later tests, the engines were measured after break-in. The engines in tests used for comparisons were measured in the same manner.

Samples of oil drawn from the engine crankcase during the tests were examined in the laboratory for their volume content of solids and resinous material. The material insoluble in petroleum ether (naphtha) was considered to be the sum of the solid and the resinous material in the oil, and the material insoluble in both petroleum ether and chloroform to be the solids in the oil, that is, carbon, dust, metal particles, and so forth.

The data showing ring, bore, bearing wear, and oil contamination are presented for the following protective combinations of air cleaners and oil filters:

Road tests—20,000 miles of normal driving on Michigan paved roads with "light-duty" and "heavy-duty" protection.

Dust tunnel tests—Various types of air cleaners—no oil filter, various types of air cleaners—with depth-type bypass oil filter, various types of air cleaners—with and without a bypass oil filter, a heavy-duty oil bath air cleaner with two types of bypass oil filters, and a heavy-duty oil bath air cleaner with several types of full-flow oil filters.

Engine-stand tests—Several types of full-flow oil filters with 0 to 5 micron dust added directly to the engine oil.

Oil contamination at the start and end of each test is given in Table 1. The volume of solids in the crankcase oil is shown in the last column. This value is probably the most important from the point of view of engine wear. The presence of resins and

Protection Factor in Engine Wear

EXCERPTS FROM PAPER BY

W. S. James, B. G. Brown, and B. E. Clark

Fram Corp.

• Paper, "Engine Wear from Abrasives in Intake Air," was presented at SAE National Fuels & Lubricants Meeting, Chicago, on Nov. 1, 1951.

solids in the oil at the start of the test is probably due to preliminary running of the engine before the actual start of the test. The following conclusions have been drawn from the data:

(1) The increased amount of dirt in the crankcase oil when the air cleaner is omitted, or its efficiency reduced, is very great (as much as 30 times).

(2) The use of an oil filter reduces the amount of solids in the oil by a very significant amount, in some cases to 1/20 or 1/30. The more effective oil filters remove practically all of the solids. This was found to be true whether the oil filter was used in a bypass or a full-flow system.

(3) The use of an oil filter reduces the amount of resins in the oil very greatly, in some cases to as little as 1/10 or 1/20 of the amount when no oil filter is used.

It was realized that the oil in the crankcase at the end of the test could not be considered to have been used for 10,000 miles because of the addition of make-up oil. To allow for this fact, an average oil mileage was estimated on the following assumption. Oil in the crankcase at any time was made up of that portion of the original charge and each oil add thereafter which would have been present if the same percentage of each oil add was used up as the percentage of the total oil volume used during each period between oil fills. Thus, by averaging the hours of use and quantity of oil add, it was possible to compute a reasonable value for the average number of hours a given crankcase full of oil had been used.

The upper half of Fig. 1 shows the relation between odometer miles and average oil miles for the car with heavy-duty protection and a 10,000 mile oil change; the lower portion, the same information for the car with the 1000 mile oil change. It will be noted that when oil is changed infrequently, the average oil mileage approaches a constant value which depends upon the rate of oil consumption—the less the oil consumption, the greater the average oil mileage.

In Fig. 2, the percent by volume of "solids and resins" and of "solids" is plotted against average oil miles for the cars with light-duty and heavy-duty protection. A logarithmic scale has been used because the values vary over a range of more than 100 to 1. Although the points on the heavy-duty protected car show considerable scatter, the best of the "light-duty" solids and resins is more than 10 times that of the best of the heavy-duty group. The same ratio of about 10 to 1 holds for the worst points of the light- and heavy-duty groups. In the case of the solids, the best "light-duty" is about 5 times as great as the "heavy-duty," and the worst are 10 times as great. As will be shown later, these ratios of contaminants do not produce wear in the same ratios. But it is of interest to note that oil in engines with good protection is in much better condition after 10,000 miles with no oil change than oil changed every 1000 miles in engines with less effective but more commonly used types of protection.

In presenting the data for the various conditions of air and oil protection used, all the results of wear on rings will be presented, then the wear on the bores, and finally the wear on the bearings. This may permit a more ready comparison of the different types of protection on these three principal sources of wear in the engine. The increase in ring gap is, of course, somewhat related to the bore wear, both depending on the amount of dirt present in the lubricating oil on the cylinder walls. The bearing wear is represented by bearing weight loss which was more readily determined than either change in bearing thickness, bearing to journal clearance, or journal diameters.

The results of the measurements on road cars will be presented first because of the natural question, "Will laboratory tests such as those run in a dust tunnel or a test stand be similar to what is actually encountered on the road?" The curves in Fig. 3 give the increase in ring gap on the two cars

run for 20,000 miles over paved Michigan highways. The car fitted with "light-duty" protection had an oil-wetted carburetor air-cleaner, no oil filter, and the oil was changed every 1000 miles. The car fitted with "heavy-duty" protection had a high efficiency carburetor air cleaner, an efficient bypass oil filter, positive crankcase ventilation, with an oil change at 10,000 miles only.

It will be seen that the ring wear with the light-duty protection, which is very commonly used, varies from 0.015 in. on the top ring to 0.025 in. on the bottom oil ring. The ring gap increase in the engine fitted with more effective protection showed a very considerable reduction in oil ring wear, with less reduction in top compression ring wear. The reduction in wear on the oil rings was about 5 or 6 to 1. This decrease in oil ring wear is probably due to the reduction in dirt in the oil from the use of the oil filter. It will be noticed as the results of the different tests are reviewed that the wear after 20,000 miles of normal operation is very similar in magnitude to that encountered in many of the laboratory tests. It is believed, therefore, that the magnitude of wear found in the laboratory work can be considered as reasonably representative of what might be encountered in actual operation.

Fig. 4 shows the increase in ring gap with various types of air cleaners and no oil filter. The values

Table 1—Oil Contamination

Air Cleaner	Oil Filter	Solids & Resins		Solids	
		Start	End	Start	End
Road Tests:					
	20,000 Miles of Operation on Michigan Roads				
Oil Wetted	None 1000 Mile Oil Change	Trace	1.0	Trace	0.3
Renewable Type A	Depth Paper 10,000 Mile Oil Change	Trace	0.1	Trace	0.04
Dust Tunnel Tests:					
	Various Air Cleaners—No Oil Filter				
None	None (4.5 hr)	0.08	6.2	0.05	4.0
Oil Bath	None (25 hr)	0.08	5.5	0.03	3.6
Renewable Type A	None (25 hr)	Trace	2.8	Trace	0.6
	Chrome Plated Top Ring—No Air Cleaner—No Oil Filter				
None	None (6 hr)	Trace	8.0	Trace	5.0
	Various Air Cleaners—Bypass Oil Filter				
Oil Wetted	Depth Paper	0.1	0.3	0.07	0.02
Oil Bath	Depth Paper	0.0	0.2	Trace	0.02
Renewable Type B	Depth Paper	Trace	Trace	Trace	Trace
Renewable Type A	Depth Paper	Trace	0.05	Trace	Trace
	Two Types of Air Cleaners—With and Without Bypass Filter				
Oil Bath	None	0.08	5.5	0.03	3.6
Oil Bath	Depth Paper	Trace	0.2	Trace	0.02
Renewable Type A	None	0.0	2.8	0.0	0.6
Renewable Type A	Depth Paper	Trace	0.05	Trace	Trace
	Various Types of Bypass Oil Filters—Heavy-Duty Air Cleaners				
100% Clean Air	None	0.05	1.3	0.05	0.25
Heavy-Duty Oil Bath	None	0.1	4.1	0.06	2.4
Heavy-Duty Oil Bath	Metal Strainer	0.1	3.4	0.06	1.8
Heavy-Duty Oil Bath	Depth Paper	0.08	0.15	0.06	0.05
	Various Types of Full-Flow Oil Filters—Heavy-Duty Air Cleaner				
Heavy-Duty Oil Bath	Type A	0.05	0.2	0.05	0.07
Heavy-Duty Oil Bath	Type B	0.02	0.2	0.02	0.18
Heavy-Duty Oil Bath	Type A—Untreated	0.06	0.6	0.04	0.23
Engine-Stand Tests:					
	Various Types of Full-Flow Oil Filters—5 Micron Dust in Oil				
Perfect	None	0.08	3.0	0.06	1.4
Perfect	Type A—Untreated	0.06	1.3	0.03	0.7
Perfect	Type B—Untreated	Trace	0.9	Trace	0.5
Perfect	Type C—Untreated	Trace	0.08	Trace	0.03
Perfect	Type A	Trace	0.7	Trace	0.28
Perfect	Type B	Trace	0.36	Trace	0.12

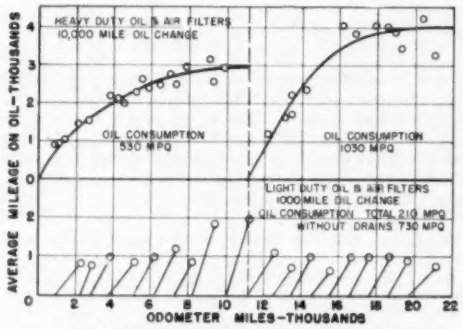


Fig. 1—20,000 mile road test on Michigan roads

The upper half of this figure shows the relation between odometer miles and average oil miles for a car with "heavy-duty" protection and a 10,000 mile oil change. The lower portion gives the same information for a car with "light-duty" protection and 1000 mile oil changes.

for no air cleaner are for a 4½ hr run. Therefore, the values that should be used for comparison with the oil bath air cleaner and the renewable Type A air cleaner should be multiplied by a factor of 5. The tremendous difference between wear with a very efficient type of cleaner, the renewable Type A, compared with no air cleaner, is approximately 100 to 1. The difference between the wear with the oil bath air cleaner and the renewable Type A is about 5 or 6 to 1 and represents the difference between an efficiency of 93% or 94% and 99%. It is of interest to note that the compression rings have about the same ratio of wear whether the wear is high or not.

The effect of using an oil filter with two types of air cleaners, one much more efficient than the other, is shown in Fig. 5. The percentage reduction in wear when the oil filter is used is much greater with the more efficient air cleaner. This is particularly noticeable in the reduction in wear on the oil rings with the renewable type of air cleaner, the reduction being in the ratio of 3 or 4 to 1, or approximately 1/3 to 1/4 of the wear when no oil filter is used. It is also apparent that the effect of cleaner oil extends as far as the second ring and probably the top ring. However, the wear of the top ring is still more affected by dirt entering the carburetor than by dirt in the crankcase oil.

The results of tests using a single type of heavy-duty air cleaner and various types of bypass oil filters are shown in Fig. 6. The top three curves show the increase in ring gap when no oil filter, an oil filter of the metal strainer type, and when a depth paper type filter are used. The difference in the wear of the compression rings is relatively small, particularly the top ring. The difference in wear between the rings when the various types of oil cleaners are used increases toward the bottom oil ring, which shows the greatest difference. This is indicative of the effect of contamination in the oil on the two oil rings. The dotted curve at the bottom shows the increase in ring gap with no oil filter but 100% clean carburetor and ventilating air. In this run, the air

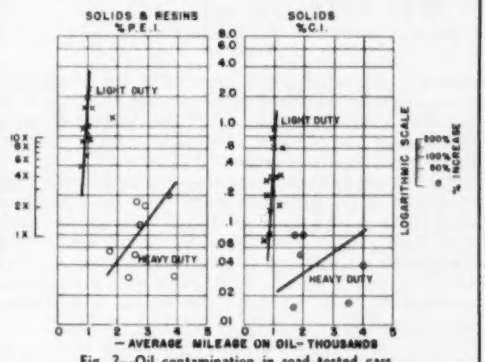


Fig. 2—Oil contamination in road-tested cars

Oil in engines with good protection is in much better condition after 10,000 miles with no oil change than oil changed every 1000 miles in engines with less effective protection.

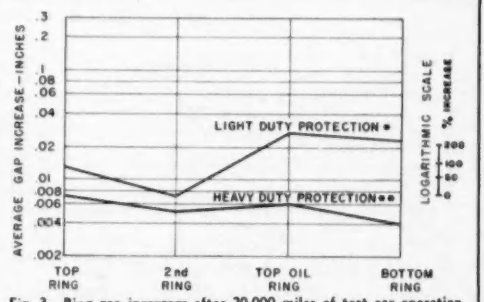


Fig. 3—Ring gap increases after 20,000 miles of test car operation on Michigan highways

* Oil-wetted carburetor air cleaner, no oil filter, oil changed every 1000 miles

** High efficiency carburetor air cleaner, bypass oil filter, positive crankcase ventilation, oil changed every 10,000 miles

The engine fitted with heavy-duty protection experienced considerably less oil ring wear than the light-duty protected engine.

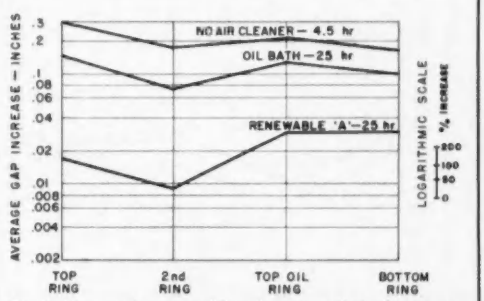


Fig. 4—Ring gap increases with various types of air cleaners—no oil filter (Dust tunnel tests—break-in wear included)

The difference in ring wear between a very efficient type of cleaner (renewable type A) and no air cleaner is approximately 100 to 1.

entering the carburetor and used for ventilation was specially cleaned through very efficient air cleaners to make certain there was no dust entering the engine at either one of these points. All the tests were run for a period of 25 hr.

Fig. 7 gives the results of tests identical with those shown in Fig. 6, except that full-flow oil filters were used instead of bypass oil filters. It will be noted that the ratios of wear between the top and bottom compression rings and the top and bottom oil rings are very nearly alike. And there is a definite improvement resulting from the use of a treatment which increases the surface activity of the filtering media. In the tests shown in Figs. 6 and 7, the break-in wear of the engine is not included.

Fig. 8 is included to show the difference in ring gap increase when full-flow and bypass oil filters are used. Average results of full-flow and bypass oil filters are compared and, as a matter of reference, ring gap increase for the road cars is shown in dotted lines. It will be noted that there is a marked reduction in ring gap increase of the oil rings when a bypass filter is used; also that the wear encountered in the road cars with light-duty protection is very similar to that encountered in the laboratory tests.

In Fig. 9, the increase in ring gap is shown when various types of full-flow oil filters are used and 0 to 5 micron dust is added directly to the oil. The top curve shows the increase in ring gap when no oil filter is used. It will be seen that a wide range of filter effectiveness can be accomplished by changes in oil filter design and construction. The range of variation between the various oil filters shown in this figure is about 4 to 1. The greater wear on the oil rings, compared to the wear on the

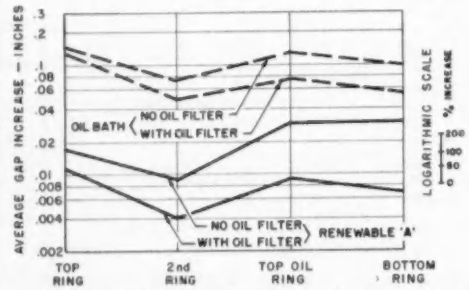


Fig. 5—Ring gap increases with and without bypass oil filters—two types of air cleaners (Dust tunnel tests—break-in wear included)

The percentage reduction in ring wear when an oil filter is used is much greater with the more efficient air cleaner.

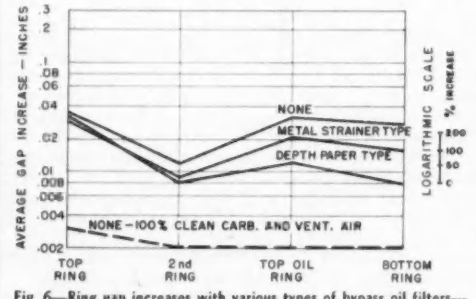


Fig. 6—Ring gap increases with various types of bypass oil filters—heavy-duty air cleaners (Dust tunnel tests—break-in wear not included)

The difference in wear between rings when various types of bypass oil cleaners are used increases toward the bottom oil ring.

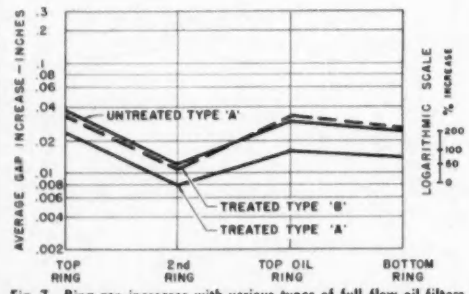


Fig. 7—Ring gap increases with various types of full-flow oil filters—heavy-duty air cleaners (Dust tunnel tests—break-in wear not included)

A marked reduction in wear is obtained by using treated-type oil filters.

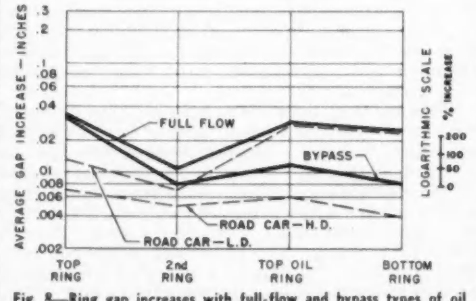


Fig. 8—Ring gap increases with full-flow and bypass types of oil filters

There is a marked reduction in ring gap increase of the oil rings when a bypass (rather than a full-flow) filter is used.

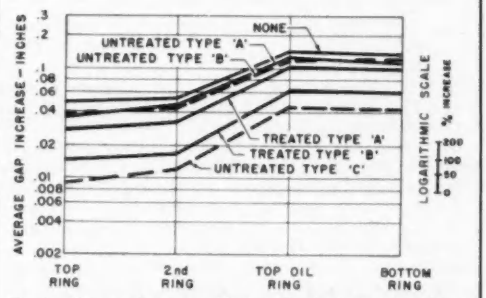


Fig. 9—Ring gap increases with 0 to 5 micron dust in oil and various types of full-flow oil filters—100% clean carburetor and ventilation air (Engine-stand tests—break-in wear not included)

Results of this test show the wide range of filter effectiveness of various types of full-flow filters. The range of variation shown is about 4 to 1.

compression rings, is very clearly shown. This, without doubt, is due to the fact that the air entering the carburetor and used for ventilation is 100% clean, and dirt is reaching the cylinder barrel and rings from the lower end. There is still evidence that the top oil ring wears more than the bottom oil ring, even though the dirt is coming from the lower part of the engine. This, again, may be due to the fact that this ring probably handles more oil than the bottom ring.

The bore wear in the engines used for 20,000 miles in test cars is given in Fig. 10. The usual high wear at the top of the top ring travel is evident, and its reduction with the use of increased protection to the engine is very clearly shown. These curves are again presented as indicative of normal road car operation for comparison with the wear results obtained under laboratory conditions.

In Fig. 11, the differences in bore wear with various types of air cleaners and no oil filter are presented. The tremendous reduction in bore wear with an efficient air cleaner, particularly at the top of the bore, is very clearly shown—being in the ratio of 40 or 50 to 1. The wear shown for no air cleaner is only over a period of 4½ hr, whereas the other two runs are 25 hr. The wear at the top of the bore for the oil bath and renewable Type A air cleaner is again in the ratio of about 5 or 6 to 1, which represents about the difference between efficiencies of 93 and 94% as against 99%.

The effect of using an oil filter with an air cleaner of about a 98% efficiency is shown in Fig. 12. The bore wear is reduced by approximately 50% over the entire range of the ring travel.

The differences in bore wear resulting from the use of various types of bypass oil filters with a single heavy-duty air cleaner are shown in Fig. 13. In this case, for purposes of comparison, a "no oil filter" curve is shown, as well as a curve of wear when 100% clean air is supplied to both the carburetor and the ventilating air and no oil filter is used. The reduction in wear with the depth paper type of oil filter is very clearly shown. Except for the wear at the top of the bore, which is principally affected by dirt passing the air cleaner, the bore wear is practically

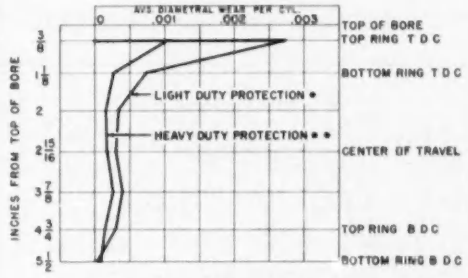


Fig. 10—Bore wear after 20,000 miles of test car operation on Michigan highways

* Oil-wetted carburetor air cleaner, no oil filter, oil changed every 1000 miles

** High efficiency carburetor air cleaner, bypass oil filter, positive crankcase ventilation, oil changed every 10,000 miles

The usual high bore wear at the top of the top ring travel was appreciably less in the heavy-duty protected engine than in the light-duty one.

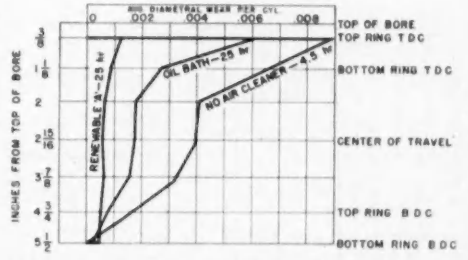


Fig. 11—Bore wear with various types of air cleaners—no oil filter (Dust tunnel tests—break-in wear included)

Reduction in bore wear with an efficient air cleaner is tremendous, being in the ratio of 40 or 50 to 1.

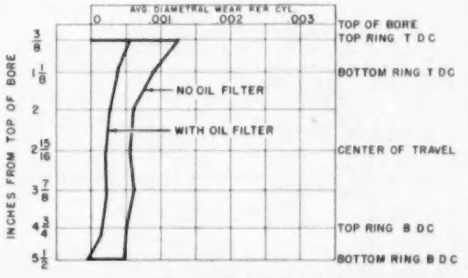


Fig. 12—Bore wear with and without bypass oil filters—renewable type A carburetor air cleaner (Dust tunnel tests—break-in wear included)

Bore wear is reduced approximately 50% over the entire range of ring travel when an oil filter is used.

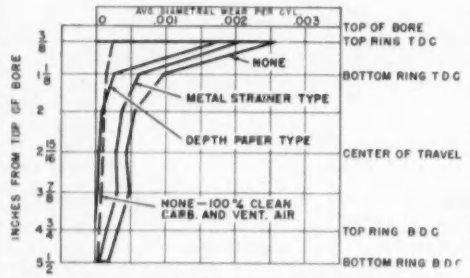


Fig. 13—Bore wear with various types of bypass oil filters—heavy duty air cleaners (Dust tunnel tests—break-in wear not included)

Reduction in bore wear with a depth paper type of oil filter is clearly shown.

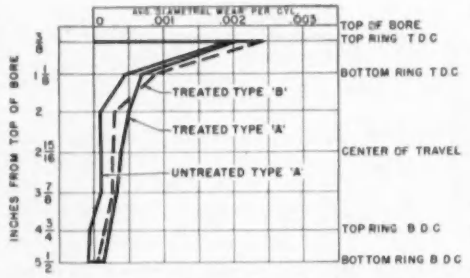


Fig. 14—Bore wear with various types of full-flow oil filters—heavy-duty air cleaners (Dust tunnel tests—break-in wear not included)

Bore wear is less with untreated full-flow filters than with treated ones.

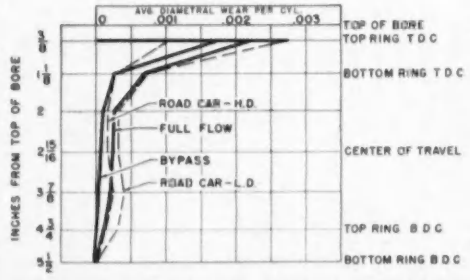


Fig. 15—Bore wear with full-flow and bypass types of oil filters.

There is less bore wear with bypass filters than with full-flow filters.

identical when a depth paper type oil filter is used and when the air entering the carburetor and used for ventilation is 100% clean.

The results of a set of tests similar to those presented in Fig. 13, except using full-flow oil filters instead of part-flow oil filters, are shown in Fig. 14. In the case of bore wear, there is apparently very little gained by the use of suface treatment in these full-flow filters, as the bore wear with the untreated unit was found to be less than either of the treated units. In all cases, however, it should be pointed out that the general magnitude of the wear is very similar to that found in 20,000 miles of operation with the normal type of engine protection.

Fig. 15 shows a comparison of bore wear with the same type of air cleaner protection but with full-flow and bypass types of oil filters. For comparison purposes, the wear with the two road cars is shown in dotted lines. As in the case of ring wear, there is less bore wear with the bypass filters than with the full-flow filters.

Results of the engine-stand tests, made with specially cleaned intake air and several kinds of full-flow filters (and with 0 to 5 micron dust added to the oil at the rate of 1 gram every 15 min for 25 hr), are presented in Fig. 16. The effect of adding the dirt to the crankcase oil is very clearly shown, the wear increasing steadily from the bottom of the bore to somewhere above the center of the ring travel where the maximum wear occurs. The wear at the top of the bore was quite low because of the use of clean carburetor air. It is of interest to note that when effective oil filters are used the bore wear is relatively uniform from the top to the bottom of the ring travel. The wear with the several oil filters varies in the ratio of about 4 to 1.

In Fig. 17, the bearing weight loss for the two engines run for 20,000 miles in test cars over paved highways is shown. The total loss in bearing weight with the lightly protected engine is very definitely greater than that of the engine with more adequate protection. Wear of the rods in the lightly pro-

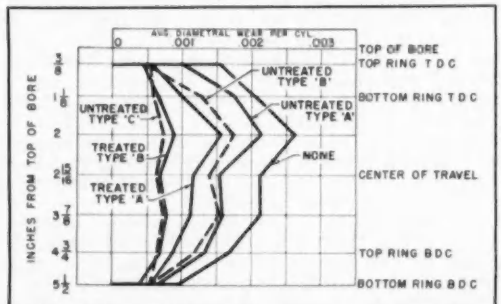


Fig. 16—Bore wear with 0 to 5 micron dust in oil and various types of full-flow oil filters—100% clean carburetor and ventilation air (Engine-stand tests—break-in wear not included)

Bore wear with different types of full-flow oil filters varies over a wide range. When effective filters are used, wear is relatively uniform from top to bottom.

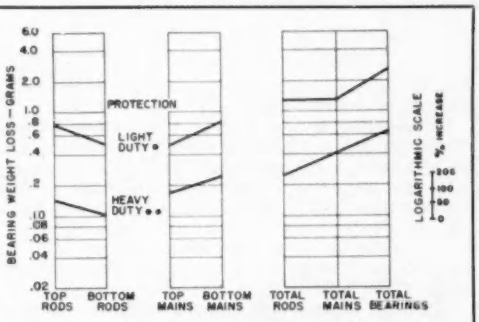


Fig. 17—Bearing weight losses after 20,000 miles of test car operation on Michigan highways

* Oil-wetted carburetor air cleaner, no oil filter, oil changed every 1000 miles.

** High efficiency carburetor air cleaner, bypass oil filter, positive crankcase ventilation, oil changed every 10,000 miles

Total loss in bearing weight with the lightly protected engine is much greater than that of the engine with more adequate protection.

tected engine is approximately 5 times that of the engine with heavy-duty protection, and in the case of the mains between 3 and 4 times. The wear on all bearings is a little more than 3 times as much with the lightly protected engine as with the more adequate protection. This is true in spite of the fact that the oil was changed every 1000 miles in the case of the engine having light-duty protection, and only at 10,000 miles in the case of the engine with more adequate protection.

The bearing weight loss with various air cleaners and no oil filter is shown in Fig. 18. The figures for no air cleaner are again those for a 4½ hr run, as compared with a 25 hr run in the case of both the oil bath and the renewable Type A air cleaner. Therefore, those figures should be multiplied by about 5 to obtain comparable values. It will be noticed that the bottom of the rods and the top of the mains have the least amount of wear. This is probably indicative of the fact that there is greater loading from cylinder pressure than from centrifugal force. As the engine was run at a constant speed of about 2900 rpm, it would seem that under these conditions the clearance between the top bearing of the rod and the crank pin is much less than the clearance between the bottom of the rod bearing and the crank pin. It is also of interest to note that the slope of the lines joining the top and bottom wear points of both rods and mains is about the same in the test engines as in the road car engines. This at least indicates that, in general, the road car loading is such that the top of the rods and the bottom of the mains are the more heavily loaded parts.

In Fig. 19, the effect of using oil filters on bearing wear is shown. Here there is a reduction in wear in the case of the rod bearings, but there is no improvement on the top of the mains and slight improvement on the bottom. In other words, there is a gain in the case of the heavily loaded bearings but less gain on the lightly loaded parts. The reason

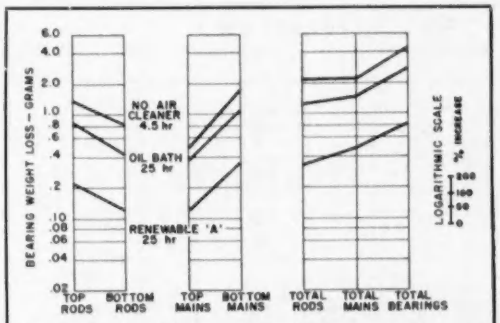


Fig. 18—Bearing weight losses with various types of air cleaners—no oil filter (Dust tunnel tests—break-in wear included)

Regardless of the type of air cleaner, the bottom of the rods and the top of the mains experience the least amount of wear.

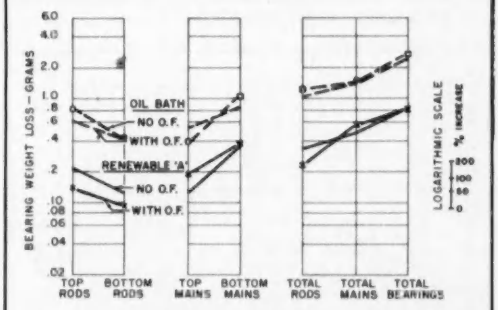


Fig. 19—Bearing weight losses with and without bypass oil filters—two types of air cleaners (Dust tunnel tests—break-in wear included)

Use of oil filters brings about a reduction in wear of rod bearings. But, in the case of the main bearings, there is no improvement on the top of the mains and slight improvement on the bottom.

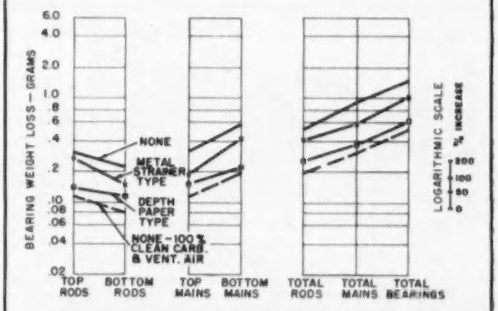


Fig. 20—Bearing weight losses with various types of bypass oil filters—heavy-duty air cleaners (Dust tunnel tests—break-in wear not included)

There is a greater increase in wear on heavily loaded parts with the metal strainer type of filter than with the depth paper type.

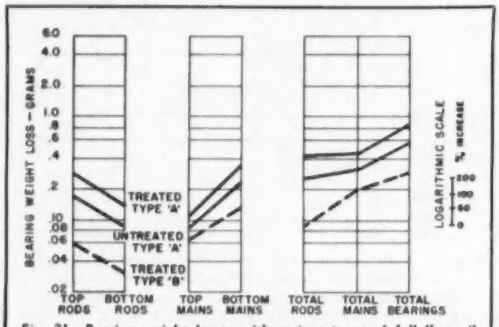


Fig. 21—Bearing weight losses with various types of full-flow oil filters—heavy-duty air cleaners (Dust tunnel tests—break-in wear not included)

There is a rather wide variation in the performance of various types of full-flow oil filters.

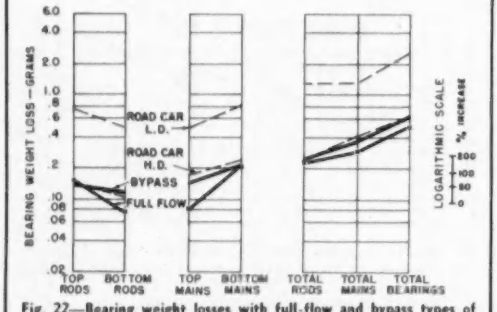


Fig. 22—Bearing weight losses with full-flow and bypass types of oil filters

Comparison of performance of full-flow and bypass types of oil filters indicates possible improvement in bearing weight losses with a full-flow filter.

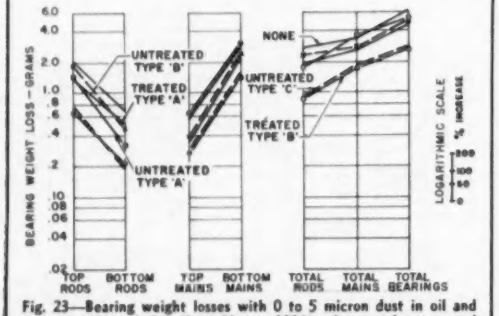


Fig. 23—Bearing weight losses with 0 to 5 micron dust in oil and various types of full-flow filters—100% clean carburetor and ventilation air (Engine-stand tests—break-in wear not included)

As in the case of ring wear and bore wear, there is a rather wide range of bearing weight loss with changes in filter design and treatment.

for this is not clear, although it may be related to the size of the dirt particles.

The bearing weight losses with various types of bypass oil filters when a single type of heavy-duty air cleaner is used are shown in Fig. 20. For purposes of comparison, the weight loss with no filter and the heavy-duty air cleaner, and the weight loss with no oil filter and 100% clean carburetor air are shown. The two bypass oil filters compared in this series of runs were of the metal strainer and depth paper type.

It will be noticed that there is a greater increase in wear on the heavily loaded parts with the metal strainer type than with the depth paper type. This would be indicative of more contamination in the oil with the metal strainer type of bypass oil filter. It might also be connected with the fact that larger size particles may pass the metal strainer than the depth paper type. These larger particles might slide through the unloaded portion of the bearing with less wear on the bearing shells. This is only a possible explanation for which, as yet, we have no experimental evidence.

The comparison of bearing weight losses with various types of full-flow oil filters when used with a single type of heavy-duty air cleaner are shown in Fig. 21. These data show a rather wide variation in the performance of various types of full-flow oil filters but a beneficial effect on bearing wear.

An estimate of the relative bearing weight losses with full-flow and bypass types of oil filters is shown in Fig. 22. These are average results of the various types of full-flow oil filters tested. For purposes of comparison, the bearing weight losses for the road cars with light- and heavy-duty protection are shown in light lines. In general, the full-flow filters show a reduction in bearing weight loss over the bypass filters. This reduction in weight loss is primarily on the unloaded portion of the rod and main bearings. There is relatively little difference between the wear of the two types of filters on the tops of the rods and the bottoms of the mains, these being the heavily loaded parts of the bearing. The comparison of performance between the bypass and full-flow type of oil filter indicates that there is a possible improvement with the full-flow filter in the case of bearing weight losses but this is not reflected in the wear on rings and bores. The reason for this difference is not apparent.

The differences in bearing wear losses with various types of full-flow filters when 0 to 5 micron dust is added to the oil are shown in Fig. 23. Here, as in the case of ring wear and bore wear, there is a rather wide range of bearing weight loss with changes in filter design and treatment. It is of interest to note, however, that the general slope of the lines connecting the top and bottom wear points of the rod and main bearings with full-flow filters, and also those shown on Fig. 21, appear to be steeper than the lines of the part-flow oil filters shown on Figs. 19 and 20.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Advantages . . . . . and Limitations of Oil Filters

EXCERPTS FROM PAPER BY

C. W. Georgi, J. F. O'Connell, and T. C. Eitel, Quaker State Oil Refining Corp.

• Paper, "Oil Filters and Additive Motor Oils," was presented at SAE National Fuels & Lubricants Meeting, Chicago, on Oct. 30, 1951.

AUTOMOTIVE oil filters have limitations as well as advantages. A lack of understanding of their function and limitations can readily lead to disappointments and to loss of the benefits which they can provide.

Since the great bulk of modern motor oils contain inhibitor and detergent additives, the extent to which these additives may be removed by different types of filters and filtering media is a matter of obvious interest. A related item is the potential removal of additives from motor oils by their adsorption on sludge particles which are then removed by the filter. Additive removal by filters can thus be considered in two separate categories: direct removal by adsorption on the filtering medium itself, and indirect removal by adsorption on sludge particles which are then removed by the filter.

In considering filter performance, a high oil flow rate through a filter is obviously desirable for maximum effectiveness. But, on the other hand, a filter cartridge must have sufficiently low porosity to trap and retain insoluble matter of reasonably small particle size. Unfortunately, high flow rate and low porosity are not very compatible, so compromises must be made in filter design.

Another factor in filter performance is sludge holding capacity, that is, the quantity of insoluble matter the filter can accumulate before it becomes "plugged up." A final item of interest relates to the effect of detergent additives on oil filterability.

Filter Test Apparatus Described

The test apparatus used in these studies is illustrated by Fig. 1. It consisted of a 2-gal tank, fitted with an agitator, heater and thermo-regulator, a circulating pump, and a pressure-regulating bypass valve. The various types of oil filters tested were of the size normally used on engines of 6 to 8 qt crankcase oil capacity.

In conducting a test, the test filter was installed and the tank charged with 7 qt of test oil. The heater and pump were then turned on and the oil brought to the desired test temperature. Automatic controls maintained the desired test conditions for the duration of each run.

An oil temperature of 160 F and a presure of 40 lb gage was used in most of the work. For the tests on solids removal efficiency, provision was made for addition of "sludge" to the circulating oil at a predetermined and constant rate.

The test apparatus thus simulated a typical filter installation of the bypass type, and of the size common to passenger car and small truck engines.

Clay Filters Efficient Additive Removers

Fig. 2 summarizes typical test results on the removal of detergent additives from oils by various types of filter cartridges. In these runs compounded oils of high detergency level, meeting the requirements for MIL-0-2104 and Supplement 1 type heavy-duty oils, were circulated through clean cartridges to study direct additive adsorption in the absence of sludge contamination.

The "inactive" type filters, utilizing various types of cotton, cellulose or treated-paper filtering media, displayed only slight adsorption or removal of detergent additives from compounded oils. Of the clay-type filters, the granulated Fullers Earth media was most active in adsorbing detergent additives, the activated alumina least active, and granulated bauxite intermediate.

Fig. 3 summarizes typical test results on the direct

adsorption and removal of inhibitor additives from compounded oils by various types of filters. Again, the inactive filters display only slight adsorption or removal of inhibitor additive from compounded oils. However, the clay filters all show a high adsorption and removal which is substantially identical in rate and extent for all three types. All of the activated clay-type filters used in these tests contained between 1½ and 2 lb of actual clay filtering media, giving a clay-oil ratio of approximately 1 lb per gal, which seems to be common in commercial installations.

Additive adsorption on filter media can be influenced by temperature, so to supplement these tests at 160 F, additional tests were run with oil temperatures of 210 and 260 F. The inactive-type filter cartridges showed no differences in additive adsorption at these higher temperatures, and for all practical purposes additive removal was nil. With the clay-type filters, additive removal by adsorption tended to be somewhat more rapid and complete with increasing oil temperature.

The inhibitor and detergent additives used in commercial motor oils vary considerably both as to chemical composition and concentration. However, all such motor oil additives have one common characteristic. They are quite different in chemical and physical nature from petroleum lubricating oil hydrocarbons, which undoubtedly accounts for their preferential adsorption on active clay filter media. A sufficient variety of additives and oils were tested to indicate a marked similarity in the rate and degree of removal by direct adsorption, and the data in Figs. 2 and 3 are typical test results for additive oils as a class.

In summary; "inactive" types of filters are indicated to have no significant additive removing action by direct adsorption. On the other hand, activated clay-type filters are indicated to be very efficient additive removers.

Fortunately, this fact is now quite widely recognized, and few automotive oil filters contain active clay filtering media. Practically all filter manufacturers now recommend clay-type filters for use only in stationary engines lubricated with straight mineral oils or for filter installations in industrial lubricating systems where gasoline or diesel engines are not involved.

Table 1—Analysis of "Reference Sludge"

	%
Pentane Insoluble	21.0
Benzene Insoluble	18.0
Sulfated Ash	10.4
Water	10.0
Approximate Composition	
Lead Salts	8.0
Other Metals, Salts, Silica, and so forth	2.0
Resins	3.0
Soot and Carbon	8.0
Water	10.0
Oil	69.0

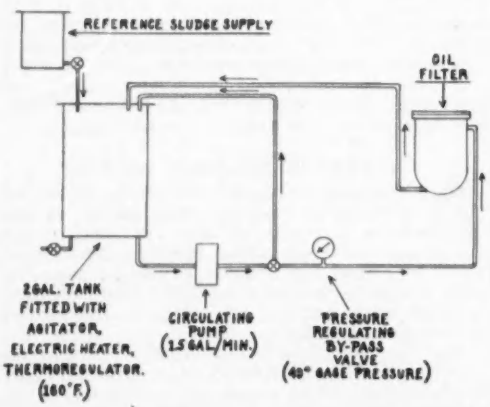

REFERENCE SLUDGE SUPPLY
OIL FILTER
2GAL. TANK FITTED WITH AGITATOR, ELECTRIC HEATER, THERMOREGULATOR. (160°F.)
CIRCULATING PUMP (1.5 GAL./MIN.)
PRESSURE REGULATING BY-PASS VALVE (40# GAGE PRESSURE)

Fig. 1—The oil filter test apparatus used in these studies simulated a typical bypass-type filter installation of the size common to passenger car and small truck engines

Filter Type, Oil Temperature Determine Flow Rate

Fig. 4 illustrates the effect of oil viscosity on the flow rates of typical oil filters of the size normally used on engines of 6 to 8 qt crankcase oil capacity. It will be noted that filter B has just about double the flow rate of filter A at any given oil viscosity, although both units are substantially identical in size.

It is significant that perfectly clean filters do not function very effectively with cold or viscous oil. If we take 1/10 gpm as a minimum flow rate for reasonably effective filtering action, filter A requires oil of less than about 400 SSU, while filter B requires oil of less than 800 sec Saybolt. A typical SAE 10W motor oil attains a viscosity of 400 sec at about 75 F, and 800 sec at about 55 F. A typical SAE 30 oil attains a viscosity of 400 sec at about 110 F and 800 sec at about 90 F. This applies with perfectly clean cartridges, and flow resistance will usually be greater as the cartridges accumulate insoluble matter. Even higher oil temperatures than those mentioned above may thus be necessary, before there is reasonably good oil flow through filters in actual use on the road.

In cold weather, many engines have to be run a

half hour or longer before the crankcase oil and filter warmup sufficiently to allow really effective filter performance. In light-duty, stop-and-start service, bypass-type oil filters may thus function at a very low effectiveness level for a considerable part of the total engine running time.

Solids Removal, Holding Capacities Vary

The filter tests for studying solids removal were made by adding "reference sludge" at a constant rate to the circulating oil sample to produce ¼% by weight insolubles addition per hour to the 7 qt oil charge.

The reference sludge was prepared by settling and separating the insoluble matter from a large volume of service station crankcase drainings. This settled sludge was in the form of a thick slurry, the analysis of which is shown in Table 1.

This reference sludge was gravity settled to a thick slurry and was not further concentrated to avoid possible agglomeration or coagulation of the insoluble matter. In this way, the reference sludge was kept nearly the same as that in crankcase oils in actual service.

Fig. 5 shows typical test results on filter efficiency

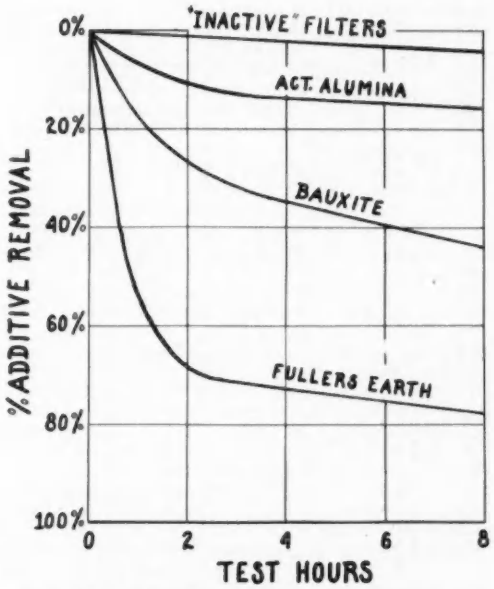


Fig. 2—Inactive-type filters displayed only slight adsorption or removal of detergent additives from heavy-duty oils. Activated clay-type filters showed much greater adsorption

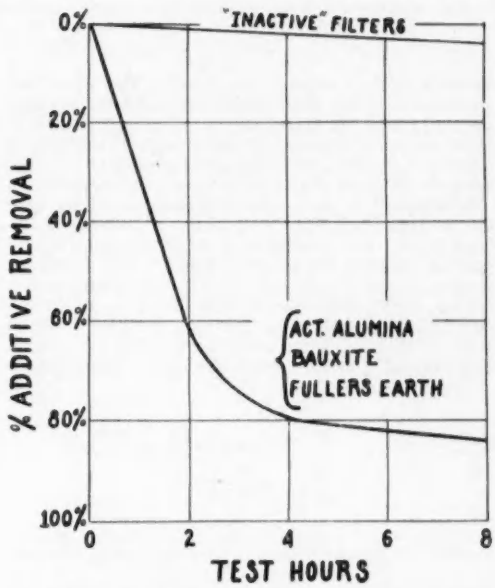


Fig. 3—Inactive-type filters displayed only slight adsorption or removal of inhibitor additive from heavy-duty oils. Activated clay-type filters all showed high adsorption

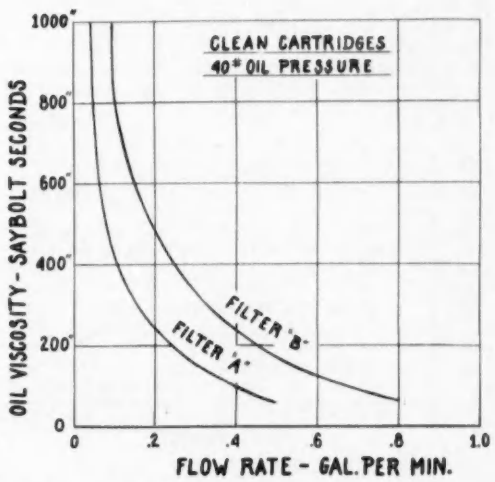


Fig. 4—Oil viscosity and type of filter determine the rate of oil flow

using a non-detergent motor oil. The rate and quantity of solids addition during a test run is illustrated by the "no filter" curve. Curves A, B, and C show the performance of three typical designs of commercial filter cartridges, and illustrate the fact that the life and efficiency of filters varies considerably depending upon cartridge design. If we take 0.4 to 0.5% insolubles remaining in the oil as the "end point" for satisfactorily clean oil, cartridge A had an effective life of some 8 test hours; cartridge B about 12 test hours; and cartridge C, 18 test hours. In net effect, cartridge A was effective up to the point the 7 qt oil charge was contaminated with a total of 2% insolubles; cartridge B to 3% insolubles; and cartridge C to 4½% insolubles. These points are shown by the arrows on the curves.

As shown by the flow rate curves, cartridge A dropped rapidly in filtering capacity or flow rate, cartridge C more slowly, and cartridge B not at all. Even though all three cartridges were run well beyond the end point for satisfactorily clean oil, the total solids collected in the respective test runs were only 5 oz in cartridge A, 10 oz in cartridge B, and 11 oz in cartridge C. With this accumulation of solids, all three types of cartridges were just about 100% filled. Significantly, these commercial filter cartridges showed more than 2 to 1 variation in overall effectiveness, even though all were substantially identical in external dimensions.

These cartridge designs are typical of three types

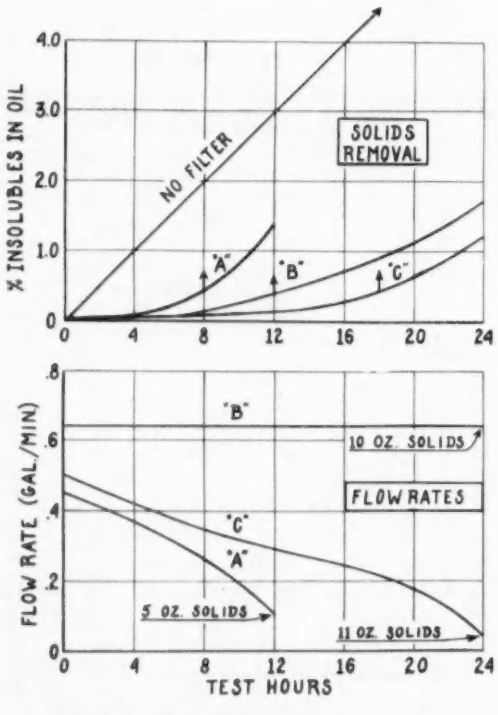


Fig. 5—Performance curves for three typical commercial filter cartridges show that life and efficiency of filters can vary considerably depending on cartridge design

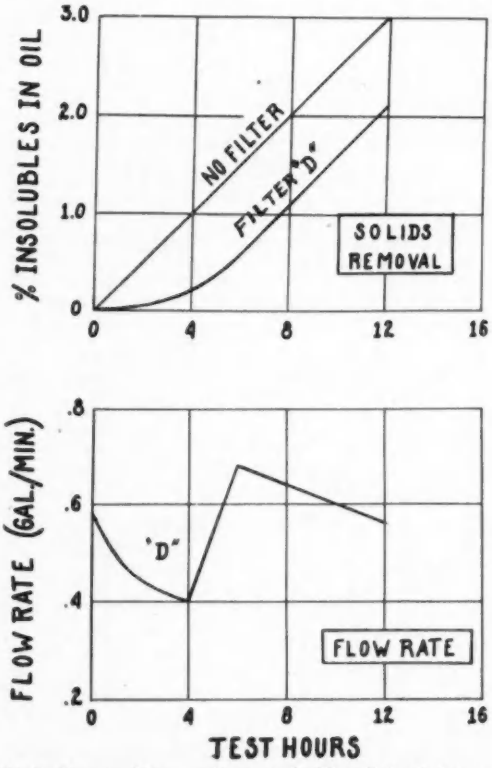


Fig. 6—On accumulating a small amount of solids, sufficient back-pressure developed in one type of filter cartridge to cause channeling and loss of all filtering action

of filters encountered in the test program:

1. Poor efficency with low solids holding capacity, plus rapid plugging and drop-off of flow rate (cartridge A).
2. High efficiency with good solids holding capacity, and fairly good resistance to plugging and drop-off of flow rate (cartridge C).
3. Intermediate efficiency as to solids removal, but with high solids holding capacity and high resistance to plugging and drop-off of flow rate (cartridge B).

Fig. 6 illustrates the performance of another type of commercial filter cartridge. Cartridge D dropped quite rapidly in flow rate during the first 4 hr of test and then developed a sharp and sudden rise in flow. Coincident with the sudden increase in flow rate, the cartridge lost all filtering action, as shown by the slope of the solids removal curve. On opening up this filter after test, the cartridge was found to be channeled, so that the oil was bypassing the cartridge within the filter case. Evidently, on accumulating a small amount of solids, sufficient backpressure developed in cartridge D to cause channeling and loss of all filtering action. It is significant that more than one design of commercial filter was found to display such channeling tendencies.

Type of Contaminant Determines Oil Filterability

It has been the rather common experience that detergent-type oils have poorer filterability than straight mineral oils or oils containing only inhibitor additives. The theory for such poorer filterability has been essentially that any detergent to dispersant action keeps insoluble matter in such a fine state of dispersion in the oil that solid particles are not as readily trapped and retained by a filter.

To study this phase of oil filtration, laboratory tests using the reference sludge were run on quite a variety of oils, ranging from non-detergent up to high detergency products of the MIL-O-2104 and Series 1 types. Some filter designs displayed no significant difference in oil filterability regardless of the type of oil tested, whereas other filters were found to be less efficient in removing insolubles from high detergency oils.

This is illustrated by Fig. 7. Filter E is typical of several designs which were tested. As shown, there was no difference in solids removal in test runs with a regular type non-detergent oil, and a typical high detergency oil of the Series 1 type. On the other hand, filter F is typical of several designs of "detergent sensitive" filters. With this type of filter, solids removal was somewhat poorer with detergent type oils.

On the basis of these tests it appears that oil filterability may depend as much upon filter cartridge design as upon oil type or detergency. This conclusion is in conflict with many experiences under actual service conditions, so some additional consideration is necessary.

The filterability of crankcase oils depends primarily upon the particle sizes of the solid contaminants in the oil. Even the finest porosity filter cartridges will not remove insoluble particles much smaller than a few microns or some 0.0001 in. in size. Normal crankcase oil contaminants are very finely divided and many particles may be considerably

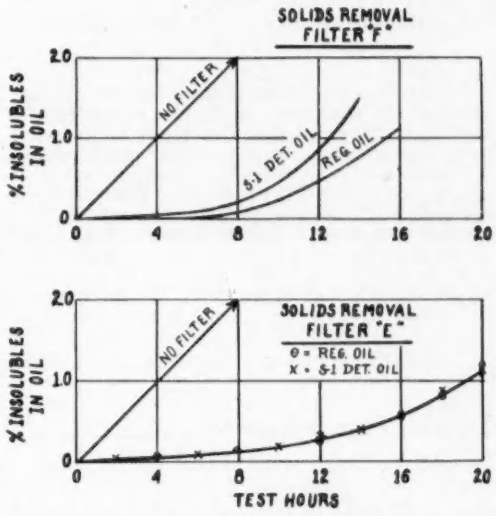


Fig. 7—Some filter designs displayed no significant difference in oil filterability regardless of the type of oil tested. Other filters were found to be less efficient in removing insolubles from high detergency oils

smaller than 0.0001 in. in size, hence unfilterable insofar as practical filtration is concerned.

Soot, which is the chief oil contaminant in diesel engines, as well as in gasoline engines operated with a large amount of starting, stopping, and idling, is apparently very susceptible to coagulation by moisture or resinous matter. But it is also very susceptible to a high degree of dispersion by detergents. Consequently, soot contamination is quite readily removed by filters when there is an absence of dispersancy characteristics in the oil, but can become largely unfilterable when the oil has sufficient dispersant action.

On the other hand, lead salts, which comprise the chief contaminants in gasoline engines operated in moderate or heavy-duty service, are not susceptible to a high degree of dispersion, one reason probably being the very high densities of lead salts. As a result, lead contamination is usually readily filterable, even from high detergency oils. Lead salts also appear to act as coagulators of other oil contaminants and thus may act as filter aids.

The situation seems to sum up this way. Where soot is the chief contaminant, high detergency oils will display poor filterability as compared to non-detergent oils. Where lead salts are the major contaminant, the difference between detergent and non-detergent oil is not so noticeable.

Detergent Additives Adsorbed on Sludge

The theory has frequently been advanced that compounded motor oils suffer additive depletion by adsorption of the additives on insoluble sludge particles, which are then removed by the oil filter.

To study this possible action, numerous analyses

for additive concentration in a variety of compounded oils were made during the course of filter test runs. To summarize this phase of the work; there was no indication of any appreciable removal of inhibitor-type additives by adsorption on insoluble matter. However, depletion of detergent-type additives was found to be quite appreciable. In a typical test on a high detergency Series 1 oil, a total of 5% insolubles was added to the oil charge over a 20 hr test period, and about 4% of this added sludge was removed by the filter. In the course of the filtration, the detergent additive content of the oil was reduced by some 20%.

Although depletion of detergent additives by adsorption on sludge particles does occur, it does not appear that such is of high magnitude except in cases where excessively high rates of sludge contamination of the oil prevail.

(Paper on which this abridgement is based is available in full in multilithographed form from SAE Special Publications Department. Price 25¢ to members, 50¢ to nonmembers.)

Excerpts from Discussion

By P. K. Kolthoff

International Harvester Co.

NO one will disagree with the authors that a filter is essential in reducing abrasive wear caused by dirt and abrasives in the oil. A filter cannot be expected, however, to reduce wear resulting from fuel dilution, so-called "acid action," or abrasives introduced with the intake air.

One of the requirements of a filter was indicated to be its ability to remove reasonably small carbon particles. When Harvester adopted full-flow filtration for its larger engines, the paper-type filter elements used were more porous than those used in the bypass-type filter. These filters pass slightly larger particles than the bypass filters, but they remove more of the large particles which can scratch bearings.

The problem, then, is to find the largest particle size an engine can tolerate and build a filter to remove everything larger. This will give the greatest filtering capacity.

Table A—Field Test Filter Performance

CAR TYPE	CAR AGE MILES	FILTER TYPE	RATE OF INSOLUBLES ACCUMULATION PERCENT PER ONE THOUSAND MILES 1ST 1000 MILES	2ND 1000 MILES	3RD 1000 MILES	4TH 1000 MILES	5TH 1000 MILES	FILTER LIFE TO OIL SOLIDS CONTENT OF 0.50%	FILTER LIFE ESTIMATED SOLIDS REMOVED PERCENT OF OIL CHARGE
CY	10000	FULL	0.1**	0.2**				> 10000	6.0
CY	15000	FULL	0.1	0.2	0.1			> 3000	> 1.6
FD	15000	BYPASS	0.1	0.1				> 2000	> 1.2
FD	42000	BYPASS	0.1	0.1	0.2	0.4		> 4000	> 2.0
PY	31000	BYPASS	0.1	0.2	0.5	0.7		3000	1.3
ME	50000	BYPASS	0.1	0.1	0.1	0.4	0.4	> 5000	> 2.2
CA	15000	BYPASS	0.2	0.3	0.3	0.2	0.3	5500	2.2
CH	9000	NONE	1.2	0.5	0.8	0.8	0.8		
CH	4000	NONE	0.8	—	—	—	—		
CH	13000	NONE	0.6	0.7	0.5	0.5	—		
BU	34000	NONE*	0.5	0.6	—	—	—		

* FILTER PRESENT BUT APPARENTLY CHANNELED OR SHORT-CIRCUITED

** TEST BEGAN AT CAR AGE 6613 MILES WITH ORIGINAL FILTER

By J. A. Edgar

Shell Oil Co.

PERHAPS it would aid somewhat in visualizing this discussion of filter life and capacity to view the bench test regime in the light of passenger car operation. How fast do solids accumulate in the oil? In the field, does the filter remove solids as the bench test predicts that it should? What, then, will be the filter life measured in car miles?

The figures of Table A were produced by owner-operated passenger cars in the San Francisco area. Service conditions were quite uniform throughout the group, being a combination of daily drives of 20 to 60 miles, about half of which were in traffic. Sludging would not be expected, but the duty was not as favorable toward filtration as steady long distance operation would be.

Inspecting now the contaminants collected in the absence of filters, an average rate of solids (pentanes—insoluble) accumulation of 0.67% per 1000 miles operation is noted. At this rate, filter A (of Fig. 7 in the paper) would gather its limiting load of solids in 3300 miles, while filter C should fill up in 7200 miles. The upper section of the table shows one full-flow filter life of greater than 10,000 miles, and one bypass type which failed at 3000 miles, another at 5500 miles. The remaining filters were not run to their life limits.

In an incomplete way, these figures seem to indicate that the bench test procedure was representative; that the character of the solids used, and its dispersion, was like that found in at least some cars on the road.

New Filtering Problems Created by

High Detergency Lubricants

EXCERPTS FROM PAPER BY

H. M. Gadebusch, Detroit Diesel Engine Division, General Motors Corp.

R. T. Karr, Purolator Products, Inc.

W. B. Bassett, Lubrizol Corp.

• Paper, "Oil Filtration Problems with High Detergency Lubricants," was presented at SAE National Fuels & Lubricants Meeting, Chicago, on Oct. 20, 1951.

USE of highly detergent crankcase oils has created a number of new filtering problems.

Detergent additives not only effectively counteract the formation of engine deposits by polar suspension of the colloidal contaminants in the oil, but also render the bulk of the organic contaminating matter unfilterable. Establishment of an efficiency-promoting sludge bed on the oil filter elements is thus prevented, and color-clean oil filtration made impossible.

This introduces the problem of when to change detergent lubricants. While viscosity determinations may be quite easily made in the field, there are no simple tests in existence for determining exhaustion of the detergency additives.

Why Detergent Oils?

Properly selected and applied filtration equipment permits maintenance of straight mineral crankcase oils in transparent condition and elimination of most of the wear caused by abrasive solids.

However, even the most efficient crankcase oil filtration has little or no effect on those engine parts whose condition governs reliability and life—the pistons, piston rings, and cylinder liners. Why? Because the abrasive material in the inlet air stream which is not eliminated by the air cleaner, as well as by-products of fuel combustion, must first pass the pistons before reaching the crankcase. This passageway is normally coated with a film of highly oxidized oil forming a perfect bond for the solid contaminants. Therefore, much of the piston ring and cylinder wall wear—and most of the deposit formation on piston skirts and in ring grooves—occurs before the oil filter ever gets a chance to render these materials harmless.

Realization of this fact confronted the oil industry with the challenge to develop motor oils which could effectively prevent the formation of deposits on these vital engine parts.

Two means were employed to achieve this goal: (1) fortification of the oil with chemical compounds —increasing its resistance to oxidation, and (2) addition of cleansing or "detergent" materials.

The results achieved in this manner during the past decade have exceeded all expectations. Use of oxidation inhibitors results in much lower oxidation levels in the oil sump and on the cylinder walls than obtainable with even the best straight mineral oils. The formation of varnish-like oxy-hydrocarbon compounds and corrosive organic acids is thus effectively reduced. The detergents, in turn, counteract the coagulating tendency of the already lowered amount of oxidation products, thus keeping the varnish-forming materials, as well as the colloidal carbon particles, dispersed in the oil.

During the early period of engine operation without oil filters, the discarded dirty oil left its sludge behind in the crankcase. In the following stage with filtration, clean oil could be drained from comparatively clean crankcases but pistons and rings still remained unaffected. With detergent lubricating oils, engine maintenance has now progressed to the point where the entire engine interior can be kept in cleaner condition than obtainable with straight mineral oils and the most perfect type of oil conditioning.

How Much Detergency?

The amount of organic contamination which can be handled by a heavy-duty lubricant will obviously be in proportion to the quantity of detergent ma-

terial present. The two sources for this type of contamination are (1) incomplete fuel combustion, and (2) oxidation of the lubricating oil. (See Table 1.)

The effect of these adverse conditions is basic for all types of engines regardless of the fuel used. Both gasoline and diesel engines are therefore equally responsive to the effects of cracked fuels, high fuel sulfur content, low combustion temperatures, and overrich mixtures. However, the method by which the fuel and air are mixed has a noticeable bearing on the formation of unburned carbon during the combustion process. Fuel injection into the compressed air, such as employed in diesel engines, generally provides less uniform mixture ratios than found in carbureted engines. Overrich mixture strata thus formed account for the considerably higher quantities of carbon "soot" contaminating the crankcase oil of diesel engines even under normal operating conditions.

To take care of the detergency requirements of both types of engines, under all possible operating conditions and with fuels of widely varying combustion characteristics and sulfur contents, the petroleum industry has made available lubricating oils of five different detergency levels. (See Table 2.)

For proper choice of one of these five types of detergent oils all fuel factors contained in Table 2 must be taken into consideration. While the light-load level of gasoline engines in passenger car use generally permits their satisfactory operation on premium or 2-104B oils, the same engines in commercial use may require the higher detergency of MIL-0-2104 oils, particularly if highly cracked gasoline is used.

Under the operating conditions for which diesel engines have become famous as low cost power producers, that is, high load factors, high oil temperatures and inexpensive grades of fuel oil, use of one of the three highest detergency level lubricants is required for longest life. As a rule, MIL-0-2104 lubricants will satisfactorily handle fuel oils with a sulfur content below 0.5%, S-1 oils will tolerate sulfur percentages approaching 1.0% and beyond that point, or under particularly severe operating conditions, superduty lubricants of the S-2 type may even be recommended.

Fig. 1—With straight mineral crankcase oil, coagulation of the colloidal carbon particles in the oil establishes a "sludge bed" on all types of filters which increases filtering efficiency

How to Filter Detergent Oils

The physical size of the carbon particles originating from incomplete fuel combustion or as the result of lubricating oil oxidation is submicronic. Their coloring value is very high, as little as 0.2% of this type of carbon visually blackening the lubricant. Color-clean filtration of crankcase oils would therefore be impossible—even with the best-constructed depth-type filters and low oil flow—if it were not for the help of the coagulating action exerted by even small amounts of the resinous oxidation products upon these colloidal particles. With straight mineral oils, this coagulation of the carbon to larger globules establishes on all types of filters a "sludge bed" which increases the filtration efficiency and can, therefore, normally be considered as a sign of satisfactory filtration.

A typical example of this condition is given in Fig. 1. The metal edge-type strainer shown has free openings of 125 microns in one dimension and should, by all rights, retain only solid particles exceeding approximately 0.005 in. Yet it has accumulated, with use of straight mineral oil, a heavy layer of carbonaceous sludge known to consist mainly of colloidal materials. Chemical analysis data of this sludge are shown in Table 3.

Since this coagulating tendency exerted by the resinous oxy-hydrocarbons is broken by the deter-

gent oil additives, the submicronic solid contaminants will appear in heavy-duty lubricating oils in their true unfilterable size. The same mechanism which effectively combats the formation of engine deposits is, therefore, likewise responsible for the impossibility to establish a filter sludge bed and the resulting blackening of the oil.

With use of detergent lubricants, oil color has therefore completely lost its meaning as a grademeter for oil cleanliness and the necessity of filter element changes. The rapid blackening of heavy-duty oils and absence of the telltale sludge deposits on used filter elements have instilled in some engine operators the feeling that, since the effects of lubricating oil filtration are no longer visible, filters could be completely dispensed with or at least the filter elements need not be changed any more.

Nothing, of course, could be farther from the truth. The cleansing and dispersing action of heavy-duty lubricants is most effective on deposition of organic colloidal contaminants and has less influence on minute metallic, abrasive, or hard carbon particles. To profit from the wear-reducing effect of oil filtration the inorganic solids must be removed from detergent oils just as completely as from ordinary lubricants.

The overall efficiency of most oil filter designs developed for use with straight mineral oils depends to a large extent on speedy establishment of a density-promoting sludge bed. Since with detergent oils this sludge bed can be no longer relied upon, the density of the filtering media must be increased to assure satisfactory filtration quality.

Detergent lubricants have supplied to the age-old question "full-flow or bypass filtration" a better answer than practically obtainable with straight mineral oils. Removal of the excess heat in high-speed engines necessitates circulation of large quantities of lubricating oil. In high output industrial engines with oilcooled pistons, oil circulation may may be as high as 1.4 to 1.8 gpm for every 10 hp or 35 to 45 gpm for a 250 bhp engine. To filter such formidable amounts of lubricant with the same degree of efficiency as obtainable with a bypass filter handling only 5% to 10% of the total flow, a full-flow filter would obviously have to be materially larger in filtering area. True full-flow filtration of straight mineral oils becomes, therefore, largely a problem of space which is usually solved by a compromise between filtration quality and filter size.

The almost simultaneous advent of heavy-duty lubricants and multifold paper filters now permits a combination of the space-saving advantages of both. By eliminating the necessity for storing the bulk of the sludge-forming colloidal contaminants in the oil filter elements, detergent lubricants have made possible a considerable reduction in filter dimensions. While this reduction would normally also produce a corresponding increase of the oil velocity, with subsequent loss of filtration efficiency, the large filtering area provided by the multifold construction may be employed to restore normal oil flow rates.

In installations where space and accessibility considerations are preventing use of a full-flow filtration unit sufficiently large to obtain the desired efficiency, combination of a relatively coarse full-flow strainer (for direct protection of the bearings against damage by larger solid particles) and a bypass filter (for gradual elimination of the wear-producing smaller solid contaminants) will give adequate overall engine protection.

When to Change Detergent Oils

Use of additive-type lubricants, together with properly selected filtration equipment, permits lengthening the oil change periods which more than offsets the higher initial cost of these lubricants. Under high temperature operating conditions where straight mineral oils would have to be discarded after as little as 30 to 50 hr, heavy-duty lubricants of the MIL-0-2104 type may be employed five times as long without any danger of bearing corrosion, piston ring sticking, or sludge deposition.

However, two factors which limit the life of heavy-duty lubricating oils should be understood. First, the fact that while detergent additives prevent the organic contamination from depositing on engine parts, they do not remove it from the crankcase. Consequently, the oil viscosity will show a gradual increase due to the dissolved and suspended organic contaminants until finally a point

Table 1—Conditions Conducive to High Organic Contamination

Incomplete Fuel Combustion	Lubricating Oil Oxidation
Poor burning quality of the fuel	Low oxidation resistance
High sulfur content	High oil temperatures
Low combustion temperatures	Low crankcase oil content
Overrich fuel/air mixtures	Excessive oil change periods

Table 2—Types of Detergent Oils

Grade Designation	Comparative Detergency
Premium	1
Heavy-Duty (2-104B)	3
Heavy-Duty (MIL-0-2104)	4.5
Heavy-Duty (2-104B)	3
Super-Duty (2-104B S-2)	16

Table 3—Chemical Analysis of Sludge

Constituent	%
Carbonaceous Material	30.8
Resinous Material	5.9
Miscellaneous Metals	4.6
Oil Content	58.7
	100.0

may be reached where satisfactory oil supply to splash-lubricated parts is no longer assured.

The second point limiting the usefulness of heavy-duty lubricants is the exhaustible nature of the detergents. Their polarizing action depends on the quantity of detergent material available in proportion to the amount of contaminating matter present. Fig. 2 represents the three theoretically possible cases. "A" shows fine dispersion of the colloids with an excess of detergent still available for handling additional contaminants. In Case B the balance has been reached, all active detergent having been used up. Case C is indicative of the final contamination stage where supply of still more contaminants will prevent the detergent from doing its duty. Incipient sludge formation will then take place in the same manner as if non-detergent oil were used.

Considerable attention has been directed during the past few years to the possible use of oil drain analyses as an indication of oxidation resistance and detergency effectiveness. Since most of the current heavy-duty oils derive their detergency from compounds containing either calcium or barium, much can be learned about the condition of used oil samples by sulfate ash determinations. These metals may thus be readily analyzed in new oils and have very definite values for each particular lubricant.

In used oil samples, however, the same metals may show up in identical amounts without necessarily indicating their presence in an effective form. The sulfate ash analysis of used oil may also be increased by presence of undissolved or dissolved organic salts contributed by iron, lead, and dirt contamination products. On the other hand, reduced sulfate ash values may be found in the used oil which could be attributed to removal of some organic compounds by effective filtration. While it is generally felt that analysis for the calcium or barium present in the detergent compound is possible after filtration of the used oil through paper, these methods are far too complicated to be recommended for field use.

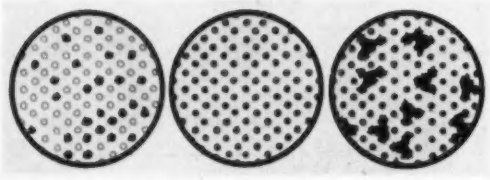


Fig. 2—This figure illustrates the exhaustible nature of the detergent in heavy-duty lubricants. Case A shows an excess of detergent still available; Case B a state of balance; and Case C lack of sufficient detergent

Another approach to determining the relative effectiveness of heavy-duty oils in service is use of some type of neutralization number. Since it is possible to show, with certain types of additive compounds, acidic neutralization numbers as high as 1.0 in new oils, ordinary ASTM neutralization number determinations using a color indicator will not give a true measure of heavy-duty oil effectiveness. The electrometric titration method for determining neutralization numbers undoubtedly provides a more complete story of effective oxidation resistance and detergency of heavy-duty lubricants. With this method the presence of a strong, as well as a weak base, can be shown. It is probably the latter which indicates the reserve alkalinity. Even at such time as the weak base becomes completely neutralized there undoubtedly will still be present a considerable amount of detergency which may be then attributed to the neutral type materials.

Suitable Field Test Needed

It is extremely doubtful if any of these laboratory methods will ever reach importance as a means for establishing suitable oil drain periods in the field. Since the case of perfect balance between detergent and contaminants represents a rapidly passing stage, the engine operator will have to choose between limitation of the oil drain periods to a point where excess detergency is always insured (Case A) or inspection of the oil filter elements for the first telltale signs of coagulated sludge resulting from exhaustion of the available detergent (Case C). In either case, the oil viscosity should be measured as assurance against excessive thickening of the lubricant by the accumulated organic contamination.

Occasionally, the observation may be made that, with continued use, the color of detergent oils gradually becomes clean. This may be caused by selective displacement of the detergent from the heavier carbon particles to the transparent oxidation varnishes. The polarizing action of the detergent may thus be completely exhausted by light-colored colloidal compounds, with the result that the discoloring carbonaceous solids will be coagulated and can then be removed by the oil filter. Consequently, with use of detergent lubricants, clean oil color, as well as sludge deposits on the filter elements, should be a warning that the internal cleansing action of the oil can no longer be relied upon and that the oil change periods should be reduced.

To avoid initial contamination of the highly detergent new oil with the contaminants stored in the oil filters during the previous period of use, filter element changes should be made simultaneously with changes of the crankcase lubricant.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

J. A. Edgar

Shell Oil Co.

The authors of this paper accept a priori that crankcase contamination is an evil thing; like sin, they are ag'in' it. Unfortunately, too many private car owners take the cynical view that wear will be passed along to the second or third owner, so that engine wear prevention is not a personally vital subject. To correct this attitude, emphatic proven demonstrations of the economy of filtration must be presented to the lay public.

In industrial equipment, as Gadebusch points out, a more enlightened attitude exists, and this has grown from solid fact. Where equipment is used until it is no longer economical to maintain it, economic wear statistics soon accumulate. Crankshaft wear is of little moment to the motorists, but in an industrial diesel it can be a source of intolerable expense unless non-abrasive oil is supplied to the journals.

We agree unreservedly with Gadebusch's exposition of the confusing effects respecting filterability which have been introduced by the modern highly dispersant oils. Whereas with pure mineral oil, visual cleanliness was a foolproof indicator of effective filtration, the fine dispersions of soot developed in the body of Supplement I or Series 2 oils are virtually unfilterable, and a cleanup by the filter of the latter oils actually indicates that the oil is approaching a dangerous condition.

A filter paper or blotter can be used to reveal exactly what a filter can accomplish toward removing soot from a given sample of crankcase oil.

Several papers have been published presenting strong evidence that the prevention of bore and ring wear in engines also depends upon the alkalinity of the oil. In other words, the usual type of compounding provides wear prevention via the alkaline property and, concurrently, a high degree of dispersant-detergent effect which also is connected with alkalinity.

Crankcase oil is in good condition while alkalinity remains, and is wholly or partially exhausted when the alkaline property has disappeared. Furthermore, when on the alkaline side, oil is very hard to strip of carbon by filtration. A blotter or filter paper reveals this by presenting a large lacy carbon spot.

It follows then that an operator can judge the quality of the oil in his engine if he will take a series of blotter spots. He will be able to estimate the soot load by visually integrating the spot size and its color; but more importantly, he can judge the remaining alkalinity or antiwear property by the extent to which the soot spreads among the paper fibers.

These observations are not presented as a complete and infallible guide to oil change practice, but are recommended as a valuable adjunct to the usual quality control practices (cited by Gadebusch) when highly detergent oils are used with filtration equipment.

By H. F. Bryan

International Harvester Co.

THE authors of this paper have given a straightforward picture of the problems of oil filtration with both straight mineral and additive-type lubricating oils.

A problem that has appeared with the use of detergent oils is how to determine the proper duration between oil changes. Laboratory analysis of "used oils" may be made to determine the activity of the additives in the oil. However, few field operations have laboratory equipment available to make the necessary determinations. There is at present an urgent need for a simple accurate field method for determining the length of drain period for different types of service with additive-type oils.

Our experience parallels that of the authors in that oil viscosity and the start of sludge formation on the filter element can be taken as fairly accurate criteria for establishing safe drain periods.

F. S. Engelking

Caterpillar Tractor Co.

The authors should be commended on their paper which brings the literature on lubricating oil filtration more up to date. We have known for some time the effect of adsorptive-type filters on compounded oils. However, many of us have wondered if the use of highly detergent oils might not modify somewhat the action of the other three types of filters. This paper answers many of the questions which have been in our minds.

We agree with the authors that color-clean oils are not necessary. Valuable filter capacity or high flow rates should not be sacrificed just to obtain color-clean oils. If a sufficient concentration of detergent is not maintained, one can expect minute particles of any insoluble materials to coagulate and be caught on the filter. This will reduce the flow rate and allow the serious contaminant dirt to bypass the filter. In other words, the detergent should have the responsibility of keeping the organic contaminant innocuous, and the filter should have the job of removing the wear-producing inorganic material.

The question of when to change detergent oils is interesting. We have much conflicting data on the use of neutralization number, per cent ash, and viscosity increase in trying to evaluate used lubricants. We are puzzled that laboratory analysis of oils has been of such little value. We believe that if a dirty detergent oil begins to clean up in appearance, the oil has been used too long. The authors have a good suggestion when they say that a sludge deposit on the filter should be a warning that the change period for the detergent oil should be reduced. Some day we hope to have a clear picture on when oil and filter elements should be changed.

L. RAY BUCKENDALE, President of SAE in 1946, died March 6, following a sudden heart attack. He would have been 60 years old on April 19.

The only native Detroiter to be president of SAE, Buckendale's many contributions to automotive engineering were made as a resident of this world center of motor vehicle design and production.

His education was in Detroit schools until he went to University of Michigan at Ann Arbor, where he graduated with a Bachelor of Engineering degree. Then he went to Timken-Detroit Axle Co. as a draftsman—and stayed to become its vice-president of engineering in 1936.

He took time out during World War I to do a major engineering job for the U. S. Army's Ordnance Department. As a captain in Ordnance's engineering division, he was sent to London to follow through on detailed design development of the Mark VIII tank; then came back to the United States to supervise production of the pilot model of that famous weapon at the Locomobile Co. in Bridgeport.

The end of World War I found him back at Timken-Detroit, but destined to make continous contributions to development of military vehicles from that time on to the end of his life. He worked closely with Ordnance engineers between World War I and World War II both as an individual and as a member of the SAE Ordnance Advisory Committee. He played a major role as a member of the SAE War Engineering Board during World War II, and, as the war neared its end, chairmanned the committee which laid out plans for the SAE Technical Board.

Then he became the first chairman of this Board, which has directed SAE technical committee activities ever since.

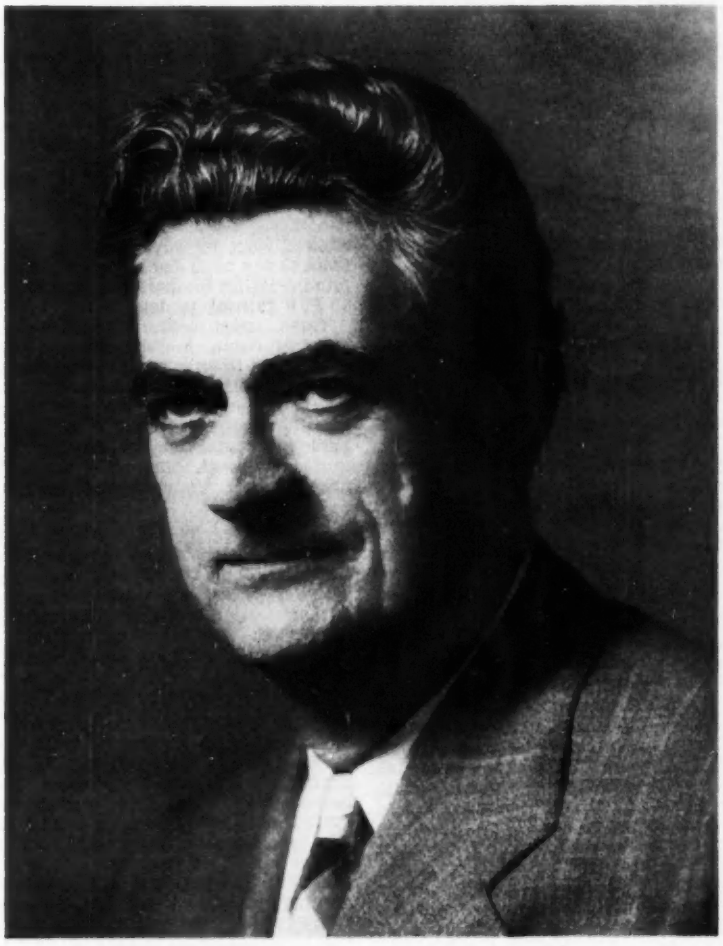
Buckendale's most important engineering contributions, through all these years, were to the motor vehicles which are the life blood of America's great service of highway transportation. A large percentage of the commercial vehicles in use today reflect, in some measure, the results of his signal engineering talents.

Ray Buckendale was an aggressive person, both as an engineer and as an executive—but, his associates say, he always refused to move until he got all the available facts. That the facts were often hard to get didn't move him to acting without them. "He is a stimulating antidote," a long-time associate once said, "to those who want to wave wands and hope for the best."

Buckendale liked to think, liked to act. . . and liked to fight for what he thought was right. He often referred to himself as "that big Irishman"—and he possessed in full measure the determination, the dry wit, and the capacity for friendships which that phrase calls naturally to mind.

High among his personal interests were books and boats. His home was at Windmill Point, a community where a boat house is as much standard equipment for a home owner as a garage.

The 1946 SAE President was a man of many abilities and widespread interests.



L. Ray Buckendale

1892-1952

Factors Affecting

CONTROLLABLE factors influencing diesel-engine starting ability are:

1. Engine design.
2. Condition of engine parts (maintenance).
3. Fuel injection pump timing.
4. Storage battery design and state of charge.
5. Properties of fuel and lubricating oils.
6. Type of cranking system.
7. Use of special starting aids.

Engine Design

Engine design influences starting ability through the effect of cranking speed, compression ratio, combustion-chamber design, and valve timing on the temperature of the compressed air charge in the engine cylinder during injection of the fuel. The type of fuel injection system also has an important effect through control of fuel particle sizes and the distribution and penetration of the full spray at cranking speeds. The effect of compression ratio and combustion-chamber design on engine starting characteristics is indicated in Fig. 1. As shown by the solid line, an increase in compression ratio tends to lower the minimum starting temperature, due to the higher heat input to the air charge. The effect of combustion-chamber design on engine starting characteristics is apparently overshadowed by other factors, although it is generally assumed that combustion-chamber designs having high ratios of surface area to volume have high heat losses to the cold combustion-chamber walls and are therefore harder to start. Cylinder bore size also has an important influence on engine starting characteristics, engines of small bore being much harder to start.

Intake valves normally close 40 to 50 deg after bottom center in order to obtain good volumetric efficiency during high-speed operation. This late valve timing reduces the effective compression ratio at low rotative speeds, especially during starting. Tests on a small hand-cranked 4-stroke-cycle engine showed that, by advancing the inlet valve closing from 43 deg to 25 deg after bottom center, the minimum starting temperature was lowered from 56 to 40 F, a gain of 16 deg.

Valve tappet clearances may have an appreciable effect on engine starting characteristics, since they are subject to change with temperature. Therefore, to insure optimum starting performance, valve tappet clearances should be adjusted at the desired starting temperature or, if adjustments are to be made at normal temperatures, increased clearances must be allowed. The use of automatic valve clearance adjusters would obviate this difficulty.

Condition of Engine Parts

The condition of engine parts influences starting ability through the effect of worn piston rings and cylinder liners, and warped valves or valve seats, on compression pressures obtained during the cranking period. Fuel injection pump wear and injection valve wear or sticking also adversely affect engine starting.

Fuel Injection Pump Timing

The effect of fuel injection pump timing on the cranking period required to start a small 4-stroke-cycle engine is shown in Fig. 2. At the optimum timing, 22 degs before top center, the engine could be started after only 2 sec of cranking. At the optimum timing for rated load and speed operation (27 degs before top center) it was necessary to crank the engine for 16 sec to obtain a start. It is fortunate that for many engines these two timing settings are approximately the same. This is not necessarily due to the type of combustion chamber used, since structurally similar designs may be very different in this respect. Since most engines are not fitted with variable timing devices, it is generally impracticable to satisfy both timing requirements; in such cases, the timing adjustment used is usually that best suited to rated load operation.

Battery Design and Condition

Unheated storage batteries are not a satisfactory source of energy for cranking the engine at subzero temperatures. First, the batteries will not take a charge; and second, since low temperatures retard the rate of chemical reactions, the energy obtain-

Diesel-Engine Starting

EXCERPTS FROM PAPER BY

James F. Blose, U. S. Naval Engineering Experiment Station

• Paper, "A Summary of Seventeen Years of Diesel-Engine Starting Tests at the U. S. Naval Engineering Experiment Station," was presented at the SAE National Diesel-Engine Meeting, Chicago, Oct. 30, 1951.

able from a battery is greatly reduced. Cranking tests on a widely used 2-stroke-cycle engine showed that approximately 1/3 as much energy was obtainable from the batteries at 0 F, and approximately 1/18 as much at – 35 F, as at 60 F. Experimental batteries are now being developed for use at these temperatures, however our latest information indicates that they are short-lived. Present types of batteries should have provision for heating the electrolyte at subzero temperatures to permit recharging.

Batteries should be kept fully charged during cold weather in order to have the maximum amount of power available for cranking the engine as well as to prevent freezing of the electrolyte. A fully charged battery (1.280 sp gr) has a freezing point of – 91 F, whereas a partially discharged battery of 1.210 sp gr has a freezing point of only – 23 F.

Fuel and Oil Characteristics

The effect of fuel ignition quality on the cranking period required to start a small 4-stroke-cycle engine at a temperature of 10 F is shown in Fig. 3. The curve shows that, while it was necessary to crank the engine for only 2 sec when using a 65-cetane fuel, it was necessary to crank for 50 sec to obtain a start when using a 34-cetane fuel. The curve also shows that little is gained by increasing fuel ignition quality beyond 60 cetane number. Unfortunately, commercially obtainable fuels of high cetane number have uniformly high—above zero—pour points, which preclude their use at low temperatures. The addition of an ignition quality im-

THE Internal-Combustion-Engine Laboratory at the U. S. Naval Engineering Experiment Station, Annapolis, Md., was established in 1933 to determine the suitability of diesel engines for use in the Naval Service, and to study combustion, fuels, lubricating oils, and accessory equipment to improve the efficiency and reliability of engines.

An important part of this program was the series of cold-starting tests made on many makes and models of high-speed diesel engines. Summarized here is some of the information about engine starting ability that has been developed during this period.

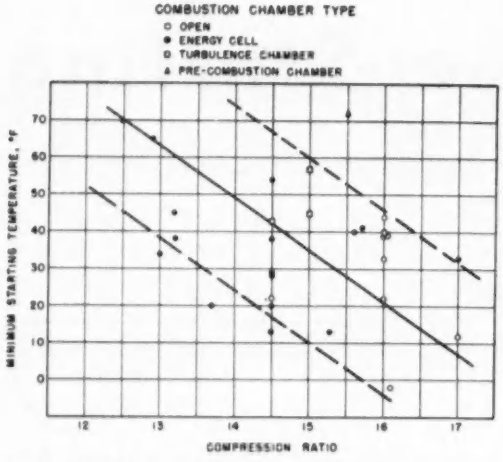


Fig. 1—Effect of compression ratio on minimum starting temperature

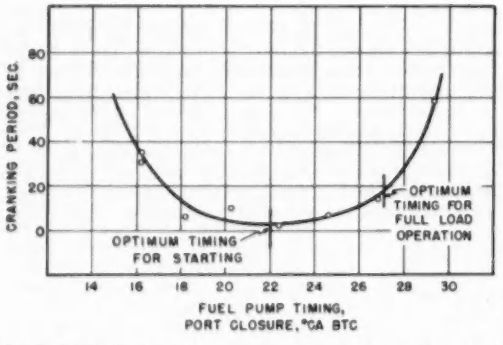


Fig. 2—Effect of fuel injection pump timing on cranking period required to start engine—60 F ambient temperature

Table 1—Comparison of Different Types of Starters (9-cyl radial diesel engine)

Type of Starter	Voltage Used	Minimum Starting Temperature, F
Cartridge	6	28
Electric inertia	12	30
Electric motor	24	22
Dynamometer	—	13

prover to a fuel of low cetane number and low pour point does not materially improve the starting characteristics of the fuel. Starting trials at other laboratories have shown that at subzero temperatures fuel volatility may be as important as ignition quality, due to its influence on the formation of a flammable mixture.

The SAE 5W lubricating oil now used for our laboratory tests has not been field tested by the Navy. It is likely, however, that if extra cooling capacity is installed and lubricating oil and jacket water temperatures are maintained somewhat lower than normal, successful operation after warming up can be obtained. It is to be hoped that such is the case since, without prior heating, other grades of present lubricating oils cannot be used. The automotive industry has found this grade of oil to be generally suitable for use in their equipment. Tests in our own laboratory, on a single-cylinder 2-stroke-cycle engine, showed higher than normal wear rates. The wear was, however, considered to be acceptable.

Cranking Systems

We have started three types of 2-cyl and one type of 3-cyl engines by hand cranking. Their displacements ranged from 60 to 86 cu in. A compression release was found to hinder rather than aid cranking unless compression was relieved on all cylinders. The best starting was obtained when using a hand-cranked inertia starter, since it was possible to store the energy input of several men for use in cranking the engine.

We have tested two types of electrical and two types of mechanical cranking systems. The electrical systems were (1) the usual type of cranking motor and (2) an electrically cranked inertia starter. The mechanical systems were (1) a cartridge starter and (2) a hydraulic cranking motor. The results of comparative tests of the first three types on a 9-cyl radial diesel engine are shown in Table 1. The cartridge starter was a device for using the expanding gases from burning smokeless powder to actuate an external piston which was geared to rotate the engine. The cranking period was very short—less than two engine revolutions—but acceleration was rapid and the cranking speed was high; hence, compression pressures were relatively high. A disadvantage of this system was that a high percentage of cartridges misfired if they were stored at subfreezing temperatures. The electric inertia starter was a standard type used for starting airplane engines and the electric cranking motor was a standard type marketed for starting diesel engines. The weight of battery used with each starting system was in proportion to the voltage used, although a lighter battery could have been used with the cartridge starter. The dynamometer cranked the engine approximately twice as fast as did the electric cranking motor.

The hydraulic cranking system consisted of a hydraulic cranking motor, hand-operated and motor-driven recharging pumps, a hydraulic accumulator, a control valve, and a sump tank, as shown in Fig. 4. When a 10-gal accumulator was used, the weight of the system was approximately the same as that of a 24-v electrical cranking system. When using a 20-gal accumulator, the system was approximately 40% heavier than the electrical system. Since the hy-

draulic motor was a constant-displacement device, the total number of revolutions cranked per trial was constant. Hence, at subzero temperatures where friction was high and lower cranking speeds were obtained, the duration of cranking was increased. The cranking speeds attained with this system were relatively high, but the cranking period was of short duration and, if the engine did not start on the first trial, it was necessary to recharge the accumulator by hand. The ability to recharge a completely discharged system by hand was an advantage, but was also very hard work. At – 35 F, four men, cranking two at a time, recharged the 20-gal accumulator to a pressure of 2000 psi in 45 min.

In general, due to the short cranking period, the engine starting ability of this device was not equivalent to that of a 24-v electrical cranking system at temperatures above 0 F. It was, however, possible to charge the accumulator and crank the engine with this system at temperatures at which the electric batteries would not function. Unfortunately, unless sufficient heat is applied to the engine prior to the starting trial, the ability to crank an engine does not ensure that it will start. The lowest temperature at which a successful start was obtained using ether fluid as a starting aid without applying external heat was - 15 F.

Special Starting Aids

Many engines now on the market cannot be started at temperatures below 32 F without the assistance of special starting aids. These most frequently take the form of heaters for the intake air.

A common type consists of an electric resistance grid in the air intake manifold, which is heated from the engine starting battery before and during the cranking period. These heaters have the fault that they impose an extra load on the starting battery at a time when the cranking load may already be excessive.

A different type of intake air heater, called a "flame primer," was introduced about 1940 and has since been adopted by many manufacturers. When using this system, fuel is sprayed into the engine intake manifold by means of a hand pump. The spray is ignited by means of a spark coil and spark plug. The products of combustion mix with and heat the intake air. This system has the disadvantage that it consumes some of the oxygen in the intake air and, if used to excess, may cause oxygen deficiency in the engine cylinders. It has, however, proved to be reliable and satisfactory in service and has the advantage that it imposes a negligible electrical load on the starting battery.

Another electrical device used to improve starting

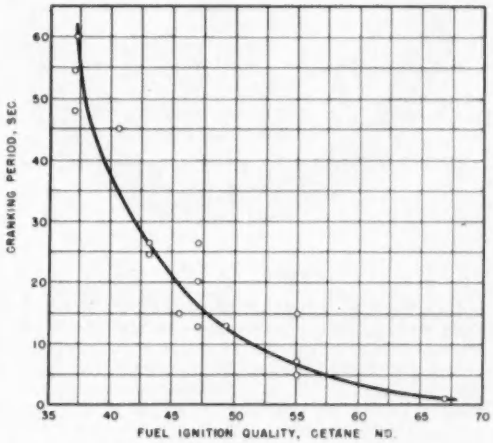


Fig. 3—Effect of fuel ignition quality on craking time necessary to start Navy engine at 10 F

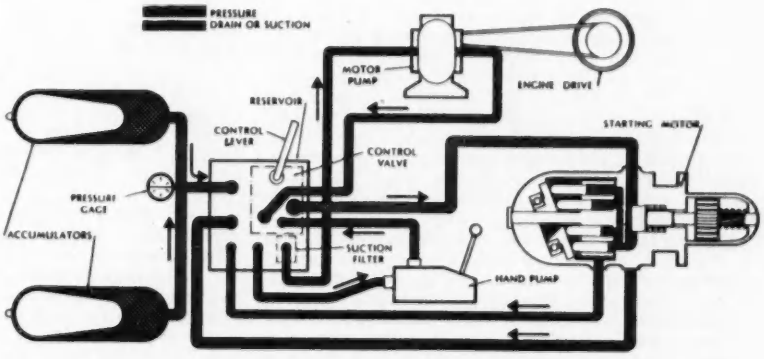


Fig. 4—Schematic diagram of hydraulic cranking system

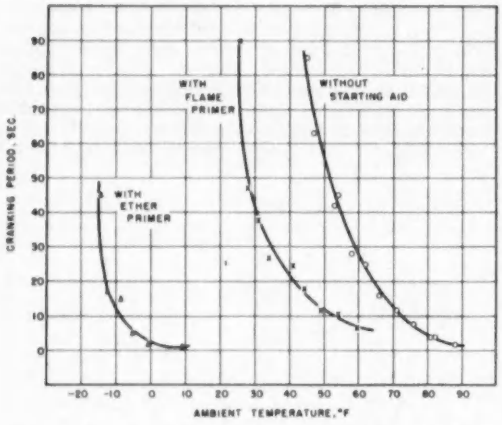


Fig. 5—Comparison of starting aids—4-stroke-cycle 6-cyl engine

is the glow plug. It consists of small coils of resistance wire installed in recesses in the combustion chambers and connected in series with the battery before and during the cranking period. The electric current heats them to a temperature of approximately 1700 F, so that they serve as an aid to ignition during starting. They require less current than an air intake heater but are less reliable in service, due to grounding by carbon accumulations and damage from rough handling during engine overhaul. When they are connected in series, the failure of one unit opens the circuit and all are inoperative.

Since high compression ratios facilitate starting, several engines have been designed with compression changing valves which were used to close off part of the combustion chamber during the starting period. On a 4-stroke-cycle, 4-cyl engine formerly manufactured by the Navy, these valves increased the compression ratio from 13.2/1 to 16.1/1 and lowered the starting temperature from approximately 45 F to 5 F. Unfortunately, these valves were hard to shift, due to carbon and lacquer accumulations between the valves and their seats. The Navy has now abandoned this feature on engines which it manufactures.

Experiments with devices to increase the quantity of fuel per injection during the starting period showed that the optimum results were obtained when the fuel pump was adjusted to inject approximately twice its normal full load delivery. In cold-starting tests, using such a device the minimum starting temperature was lowered only 7 F, from 43 to 36 F, but the cranking period required to obtain a start was shortened over a temperature range of 20 F, from 60 to 40 F. In our experience with this device, no excessive quantities of fuel were found in the lubricating oil. The improvement in starting was attributed to the formation of a more readily combustible mixture consisting, for the most part, of the more volatile constituents of the fuel.

The best of many special starting fluids which have been tried experimentally is di-ethyl ether. Its beneficent effect is attributed to its low spontaneous ignition temperature, its high ignition quality, and its wide range of flammability. The best results were obtained when ether was sprayed into the engine air intake manifold at the same time that the engine fuel injection system was furnishing fuel to the engine cylinders in a normal manner. The results of comparative tests between a flame primer and an ether primer on a 4-stroke-cycle engine are shown in Fig. 5. The minimum starting temperature with the flame primer was 25 F, whereas the minimum starting temperature with the ether primer was −15 F. The usefulness of ether is apparently limited by its low vapor pressure at subzero temperatures, 38 mm at −22 F, compared to a vapor pressure of 442 mm at 68 F. Cold room tests on four engines showed that each could be started at temperatures down to −15 to −20 F. At lower temperatures, the volatility of the ether appears to be insufficient to form a combustible mixture unless heat is added.

Ether starting fluid may be obtained in bulk, in gelatin capsules, or in metal pressure primer cartridges. The pressure primer cartridges are the safest to handle, tests having shown that they will not explode or leak at temperatures below 600 F. When ether is purchased in bulk or in gelatin capsules it is sprayed into the engine intake manifold by means of a hand priming pump and atomizing nozzle. The pressure primer cartridges are charged with 7.5 ml of ether starting fluid and a combustible pressurizing gas under approximately 600 psi pressure. They are closed with welded seals. The cartridges are used with a pressure primer gun, which is a device for piercing the metal seals in the end of the cartridges. The pressurizing gas expels the fluid and is used to spray it into the engine air intake manifold.

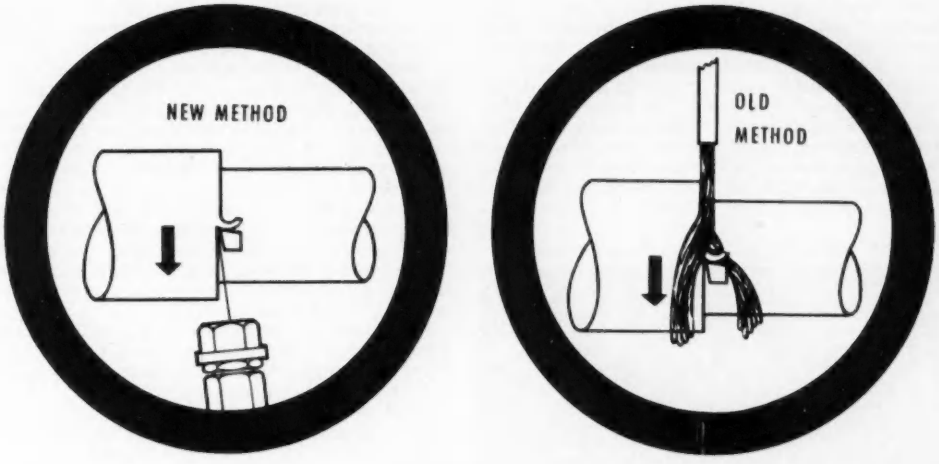
Further Improvements

Possible means for further improving starting at subzero temperatures are (1) use of very high compression ratios; (2) installation of engines and batteries in heated compartments; and (3) development of special fuels, lubricating oils, and batteries.

Some starting system not dependent on electric storage batteries and capable of being recharged at subzero temperatures by other than manual labor is desirable. Another suggested solution is the installation of the engine and battery in a well-insulated compartment with a thermostatically operated starting switch designed to start and operate the engine whenever the temperature of the compartment should approach the limit below which starting would become difficult. The switch should also be designed to secure the engine when the jacket temperatures reached 110–120 F.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Squirt Outdoes Flood



In Cooling Cutting Tools

BASED ON PAPER BY

R. J. S. Pigott and **A. T. Colwell**

Gulf Research & Development Co. Thompson Products, Inc.

• Paper "Hi-Jet System for Increasing Tool Life," was presented at SAE Annual Meeting, Detroit, Jan. 15, 1952. (This paper will appear in full in SAE Quarterly Transactions.)

JET cooling will help machine tools break clear through today's ceilings on metal-cutting productivity. It can easily triple tool life or double cutting speeds, and bring lots of other plus values too. That's because the high-speed jet of coolant does something that conventional flood cooling doesn't do: It reaches the heat-generating source in metal cutting—the point of contact between work piece and cutting tool.

Squirting a high-speed jet up at the cutting operation from below (see Fig. 1), instead of inundating it from above, brings a five-way gain:

1. For a given tool life, cutting speeds can be increased three to four times.

2. If cutting speeds remain the same, the tools themselves will last three to 12 times longer between grinds. Result: less machine down time for replacing tools and fewer man-hours spent in sharpening tools.

3. Smoother machined surface finish may eliminate machining operations. One cut may take the place of a rough cut and a finish cut.

4. It takes about one-twentieth the amount of coolant to cool and lubricate.

5. Hard-to-machine titanium and stainless steels become easier to cut.

Shooting the jet at the point of machining contact both cools and lubricates. You know it does a cooling job because you don't get the usual blue chips. At normal speeds the chips are cool enough to catch in your hand. Then too the jet stream contacting the hot tool creates considerable smoke and vapor. Laboratory tests showed that the large

tool life increases come from the fact that cooling is two to three times more efficient than with overhead cooling.

There also is proof that the new method actually lubricates the tool edge. First, the tool's nose does not fail or wear appreciably. Failure generally comes from a washout at the outer edge of the cut farthest from the jet. Second, the finish from an undamaged tool nose decreases in roughness from 260 microinches to 50. The finish looks like that from a finish cut, and the piece could go directly to a finish grind. Third, diameter changes only 0.001 to 0.002 in. in the last few seconds of cut; otherwise the diameter is completely uniform. With the overhead method, diameter increases 0.015 to 0.030 in. continuous along the cut. Fourth, and most important indication of lubrication, there is no build-up because the oil wets the top face of the tool.

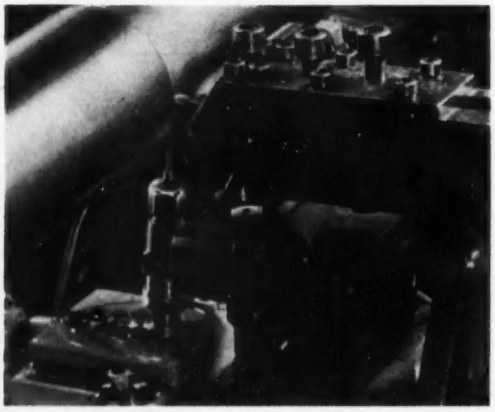


Fig. 1—A small jet of cutting fluid directed at the point of cutting contact both cools the tool and lubricates the chip sliding over the tool

It's easy to see that the jet brings lubrication to the tool edge, but much tougher to explain how it happens. After all, how does a jet pressure of 400 psi force oil past contact pressures of about 50,000 lb? This seems to be a logical explanation:

The cut face of the work has a roughness of about 50 microinches while the tool edge has a roughness of only 6 to 10. It's pretty obvious from this that the work piece is not cut by the tool, but sheared ahead of it. That accounts for the difference in roughness. That also means that tiny grooves over the edge, 10 to 60 microinches deep, are available for passages.

These tiny passages probably have too high a viscous resistance to pass oil as a liquid. But oil at the tool edge is boiling, and oil vapor can be passed by the static pressures available and is condensed again to liquid oil on top of the tool. See Figs. 2 and 3.

Just exactly what happens, nobody knows. It may be that we get a film of molecular dimensions that does much of the lubricating.

Boiling action on the tool edge seems to be somewhat critical. Too high a jet speed could sweep the surface too fast. That would lower the boiling rate and cut down heat transfer.

Tests were run at pressures from 250 to 600 psi. Fig. 4 shows that there is a definite critical pressure. It may vary with material, tool, and cutting liquid.

Shop Experience

While the explanations of how Hi-Jet works may still be theoretical, the results it produces are proof positive of its effectiveness. A case in point is the shop experience Thompson Products had in machining TPM, a new Inconel-type alloy for aircraft exhaust valves. It's a good valve material, but is tough and gummy, and is rough on tools. It contains about 75% nickel.

On one operation, rough turning of the valve stem on a turret lathe, life of a tungsten carbide tool

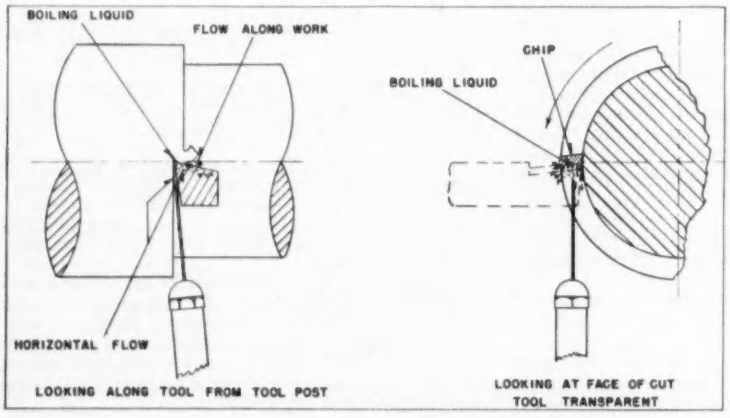


Fig. 2—This is how jet of fluid lubricates. Hot cutting tool and work piece vaporize the fluid. The vapor condenses on top of the tool, past the cutting edge. This gives the sliding chip an oily film to slide over and cuts heat from friction of chip moving over tool

averaged about 15 valves. The poorest showing was 2 valves, but that was probably due to faulty tools. Under controlled conditions, an average of 57 valves per tool grind was machined.

A production lathe was fitted with three, four, and five closely spaced jets directed up from below and bisecting the angle between tool and work. Using Gulf's new Hi-Jet oil, average number of valves per tool grind was increased to 275.

In Fig. 5 are shown results in cutting SAE 1045 steel on a lathe. Cutting speed is plotted against tool life. With the carbide tooling, metal was removed 20% faster with Hi-Jet cooling and Hi-Jet oil as against conventional overhead flooding with a 1 : 40 mixture of soluble oil and water. And for any given cutting speeds, the tools last three times as long.

Performance of high-speed steel tools is shown in the lower portion of Fig. 5. For example, for a 60-min tool life, metal can be removed 45% faster with the Hi-Jet method than with overhead flooding.

Handling time often equals cutting time in tyical turret lathe production operations. So a 20% increase in metal cutting rate with tungsten carbide tooling means a 10% saving in floor-to-floor time for the piece being machined. The floor-to-floor time will be cut even more where cutting time is greater than handling time.

Smoke Control

While the Hi-Jet method multiplies productivity of metal-cutting equipment, the method is not without its problems. One of them is the objectionable smoke and vapor it creates. This seems to support the theory that the jet stream is being vaporized when it contacts the hot portion of tool and work. But the smoke has to be disposed of. And to do it with either an electrostatic precipitator or commercial water-wash fume separator would be too expensive.

For economy, an oil curtain technique was developed to surround the tool from above and below. See Fig. 3. Note also a center flooding pipe for

Hi-Jet generates vapor . . . . . which oil curtain suppresses

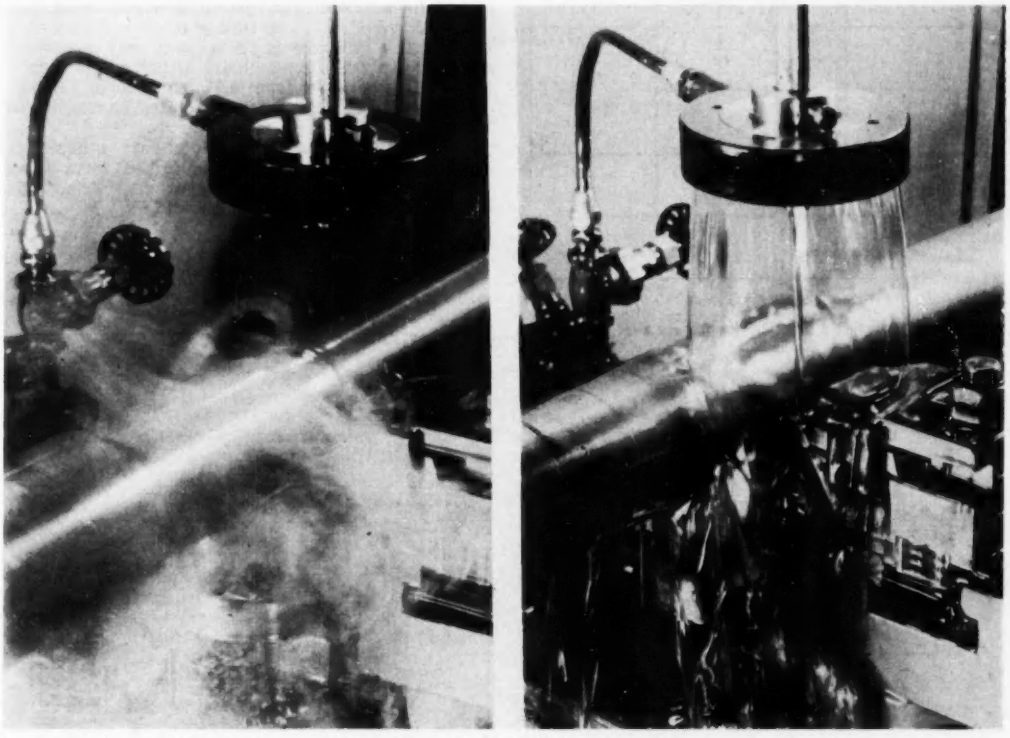


Fig. 3—Normally a machining operation generates considerable smoke with the Hi-Jet system (left). Surrounding the cutting operation with an oil curtain quenches the smoke (right)

inundating the smoke-producing area with a blanket of oil.

The oil for center flooding and for the curtain is supplied by the conventional coolant-circulating pump on the machine. The smoke and vapor has to pass through the blanket and the oil curtain. In the process it's pretty well absorbed.

Chips are another thing that have to be guarded against. Since the chips come off in fairly long curls, they have to be stopped from twisting underneath the work and interfering with the high-speed jet. It's fairly simple to devise a metal guard to direct the chips upward and away from the tool.

There will be other problems too in applying Hi-Jet to various type metal cutting operations. The method is practical for use with single-point or form tools, milling machines, gear cutting equipment, and grinding machines. But for turret lathes, an indexing valve will have to be designed to feed the nozzle on each tool. Installations also will have to be worked out for milling, shaping, broaching, and drilling.

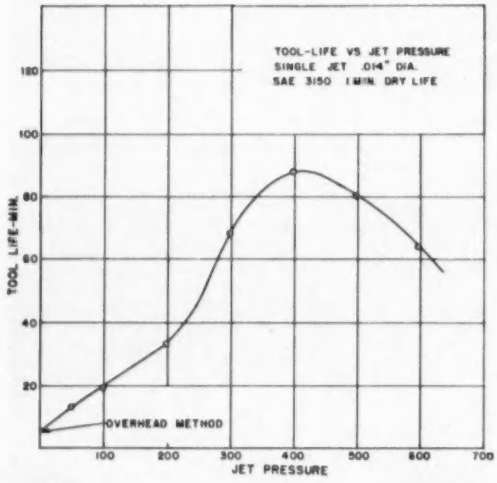


Fig. 4—Tests show that a particular jet pressure gives best tool life

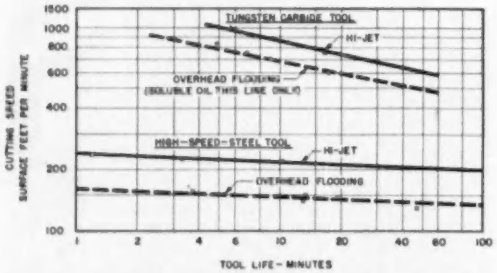


Fig. 5—With either tungsten carbide or high-speed steel cutting tools, the Hi-Jet cooling system permits higher cutting speeds. These lathe-turning tests on SAE 1045 steel also show that for a given cutting speed, tool life can be increased

Description of System

The Hi-Jet system presently recommended for turning operations is shown in Fig. 6. The coolant supply pump on the machine is not disturbed. Its discharge flow is divided, most of it going to the overhead curtain and center flooding.

Oil for the Hi-Jet system first passes through a commercial filter. The filter cartridges can be replaced in a few minutes. The cartridges will operate about two weeks, depending on conditions. The pump suction gage will show when the filter is becoming plugged. A fine-mesh screen ahead of the pump prevents metal particles from getting into the system while the filter cartridges are being replaced.

The Hi-Jet pumps so far used are the gear or vane type, with pressures of 400 to 600 psi at a flow of 1 gpm. Since each jet flows only about 1/10 gpm, this size pump is adequate even for long cutting edge tools needing five or more jets.

The elements enclosed within the dashed lines of Fig. 6 have been packaged as a unit by Thompson Products. A simple plumbing job and electrical connections to the motor complete this portion of the installation.

Nozzles and nozzle holders also have been designed for adapting the system to widely-used type production lathes. The nozzle itself consists of a body with a fine screen. A screwed cap holds and seals a flat plate into which are drilled the jet holes, ranging in diameter from 0.010 to 0.020 in. Development work is under way on plates having up to 13 jet holes.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

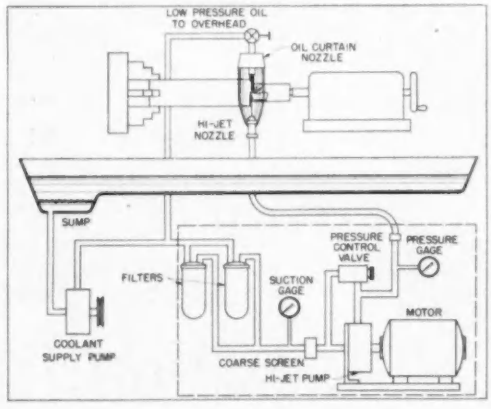


Fig. 6—Schematic drawing of the Hi-Jet installation for a lathe

. . . . New Horizons for Aero Machining

Bigger plane parts and tougher engine materials demand that aircraft industry come up with new techniques and equipment, note production men at Los Angeles forum.

REPORTED BY

Malcolm F. Judkins, Chief Engineer,
High Temperature Alloys Division, Firth Sterling Steel & Carbide Corp.

• Aircraft Production Panel on Machining was held at SAE National Aeronautic Meeting, Los Angeles, Oct. 3, 1951, under the auspices of the SAE Production Activity. Moderator was Michael Field, Metcut Research Associates.

THE bigger and more powerful airplanes grow, the more curves they throw at production engineers who have to machine components for these behemouths of the air. Machining Panel members swapped ideas with shop engineers on how to fabricate bigger parts and tough heat and corrosion-resistant materials. They told of heftier machine tools, new techniques and equipment, and new cutting fluids working their way into airframe and plane engine factories.

Wing skins are a case in point of the "beef" being built into airplanes. Instead of being made of aluminum sheet built up with thousands of rivets, ribs, and stiffeners, sections for some planes now are machined from solid slabs with the stiffeners made integral with the panel. For example, a bottom wing panel for one airplane, weighing 362 lb, is hogged out of a 3340-lb slab of 75ST aluminum $1\frac{7}{8}$ in. thick, measuring 4 ft by 30 ft.

This panel is machined on a rise and fall Onsrud machine at conventional speeds and feeds. After flat machining, the panel is stretch formed to airfoil contour and blended to form the leading edge. Larger skins are cut on planer-type milling machines.

Industry Gets New Machine

The latest equipment for machining integrally stiffened wing sections was built by Giddings and Lewis to Lockheed specifications. It will handle slabs up to 10 ft wide by 34 ft long. The machine has three vertical spindles with separate 100-hp drive motors. It can cut metal at the rate of about 600 cu in. per min. A chip conveyor that extends the width of the machine together with chip deflectors get rid of chip disposal problems.

The work is held on a six-segment, bed-length vacuum plate. The plate is adjustable by shims and four corner posts to produce taper in any direction.

Plates less than $\frac{5}{8}$ in. thick, are usually straight enough for good vacuum holding; thicker plates may have to be surfaced with a fly-cutter. Warping is not a serious problem. Sometimes the skins curl in the right direction.

Power brake bending before insertion in the stretcher die removes any warp. No special inspection is made for hidden flaws. Measuring the thickness in the center of large panels is difficult. The supersonic reflectoscope offers an out; but its relatively high cost limits its use.

The leading edge is end milled at 3600 rpm using a 50-hp motor. This operation should be greatly speeded up by the new G&L mill. Carbide cutters easily give the required microinch finish.

The plate is held with leading edge clamps in addition to the vacuum chuck whenever possible. The chuck holes are sealed by a groove around the plate edge with a molded rubber lip held down by the plate. If any tendency to curl might bring un-

Members of the Machining Panel were (left to right): W. M. Williams, chief factory engineer, Thompson Products, Inc.; N. A. Lombard, staff assistant to general manager, Santa Monica Division, Douglas Aircraft Co., Inc.; Secretary Malcolm F. Judkins, chief engineer, High Temperature Alloys Division, Firth Sterling Steel & Carbide Corp.; Moderator Michael Field, partner, Metcut Research Associates, Co-Moderator B. A. Willsey, manager, Mfg. Division, Solar Aircraft Co.; and S. N. Bean, chief tool engineer, Lockheed Aircraft Corp.

wanted thickness variation, a preliminary cut is taken to weaken the skin and allow the vacuum (27 in. hg) to flatten the work.

Spar Cap Milling

Another airframe member that's become tougher to machine because of its dimensional growth through the years is the spar cap—the flange on the main structural member in a wing. At first spar caps used to be pulled through cutters with cables. But production quantities during World War II made it necessary to design special spar milling machines. Rapid removal of large metal masses became a must.

After 1942 Douglas Aircraft standardized on one cutter design. This 9-in. diameter cutter, with three to five teeth, was operated at 3600 rpm. With carbides, it could remove up to 5 cu in. per hp per min. The present average is 3.5.

Douglas, a long-time believer in specialized equipment, now has improved spar milling equipment, with powerful enough motors and rigid fixtures.

At the Long Beach plant, a Cincinnati taper mill produces surfaces finishes of 10 microinches. In production, finishes of 15 to 20 microinches are easy to get. With a conventional Farnham machine, 60 microinch finish is common.

A good, rigid machine, high HP, extreme fixture stability and balancing of cutters and motor rotors are all important to best results.

Previously caps were removed from the machine and hand finished. Now they are sand blasted in place. With integral gas tanks, a thick web must be produced. 75ST is easier to mill than other metals. Years ago it was difficult to obtain required strength in parallel web sections 0.09 in. thick. This problem was eventually solved by highly specialized cutter design to prevent over-heating.

Jet Blading Manufacture

Just as integrally stiffened wing panels and spar caps are critical to airframe production men, so blades and buckets for gas turbines are keeping shop men busy in engine and engine supplier plants. Experience of Thompson Products, Inc. reported at the meeting showed that new machines are making the job easier.

New continuous Foote Burt broaches can now produce 1000 compressor blades per hour. Vertical broaches turned out only 300 parts per hour. And the new continuous machines also permit use of women operators.

Thompson Products has two J&L dual wheel grinders which are somewhat similar to the new Excello. The grinding machine has a definite place in the jet field because most of the precision cast materials are considered unmachinable. It is not necessary to grind S-816, Inconel, or the Niamonic series. G. E. buckets are ground at the rate of 30 pieces per hour compared to 300 to 700 with the continuous surface broach. The broach tool cost is about equal to grinding cost. The latter consists of 4¢ wheel cost, 3½¢ diamond cost compared to 9½¢ for broaches; but the productivity of the broaching method far exceeds grinding.

The J&L design is based on their thread grinding machine. The buckets are ground in nine passes, while the wheels automatically advance, removing up to 0.090 in. in 1 min and 5 sec. From 0.002 to 0.003 in. are taken in the last pass after dressing the wheel. Thompson has a Reid-thread rolling machine which may be used to develop a circular blade mounting resembling an interrupted thread. The accuracy required on the Christmas tree root form comprising 2 to 6 serrations is plus or minus 0.0005 from true form.

Powdered metal blades also came up for discussion. Thompson's TP-1 copper-impregnated, sintered powered iron blade, is made in a hydraulic press in very much like other powdered metal products. Compressor stator blades are molded or briquetted, followed by sintering, copper infiltration, and then coining. Powdered metal alloys for turbine buckets are in the experimental stage. The powdered iron blades are limited to compressor stators. These blades have very good damping properties and are used in the J-35 Allison interchangeably with 403 stainless.

New Cutting Fluids

It was said that Thompson Products originally used carbon tetrachloride with cutting oil in broaching the jet engine turbine rotor disc. Now 10 to 15% of the carbon tetrachloride is used with Sultran B-5 compound, and Stuart's 25 has been used without carbon tetrachloride with fair success; but they are reluctant to dispense with the latter. Because

of the toxic effects of carbon tetrachloride, it is necessary that the broach machine be well hooded. The carbon tetrachloride concentration is maintained by checking specific gravity hourly and replenishing. The exhaust system for a 90-in. La Pointe Surface Broach consists of an exhaust manifold 90 in. long on each side. It costs about $5000 per machine to install the ventilating system. Some states prohibit the use of carbon tetrachloride.

A problem exists of chip adherence to broach teeth and care is needed in broach cleaning. It is easier to remove chips when using carbon tetrachloride. An expensive wheel can be scrapped if chips are not removed by brushing between each pass.

Machining Corrosion-Resistant Materials

The free machining steels present no problem, but austenitic and high temperature steels are troublesome. A serious problem exists in turning, milling, drilling, and tapping. Specific feed-speed recommendations are impossible. Tool materials are rated by abrasion resistance, hot hardness, shock resistance, and ability to take and maintain keen edges. The largest hazard in the machining of stainless is the danger of vibration through improperly conditioned or adjusted equipment.

Solar Aircraft now uses up to 120 grit finish on tools and plans to use 400 grit for carbide and vapor blasting for high speed steel. Refined edges increase tool life up to 100%. Soft carbides are used for roughing cuts at about 350 fpm. Hard carbides take finishing cuts at 750 to 950 fpm. Cimcool has given good results as a fluid.

Stainless Steels

In general there are these three types of stainless steels:

1. The ferritic—which is a low carbon chromium iron alloy, nonhardenable and relatively easy to machine.
2. The martensitic—which is a higher carbon chromium iron alloy which can be hardened by quenching and tempering. This material machines much the same as other alloy steels of equivalent carbon content and hardness.
3. The austenitic types—which contain more than 7% nickel and usually more than 18% chromium. These steels are not hardenable by heat treatment, but have a very high work-hardening capacity and are the most difficult to machine.

Stainless steels are the beginning of high temperature materials. Types 347 and 403 are used in jet engines around 700 F and retain their corrosion resistant properties. Above 700 F, it is necessary to go to super alloys because the physical properties of ordinary steels diminish rapidly at moderately high temperatures.

Most of the super alloys are not steels because the base or matrix is not iron, but may be cobalt, nickel or some other heat resistant material.

We first encounter steels like Timken 16-25-6 whose properties are developed by both heat treatment and hot-cold work. Materials like inconel and nimonic are very low in iron and machine more like austenitic stainless than ordinary steel. All have very high work hardening tendencies. One can drill a ¼-in. hole only with a heavy radial drill press with steady pressure; but it is impossible to core such a hole up to ¾ in. because of work hardening.

An additional bad feature of super alloys (from a machinability standpoint) is their high strength at high temperatures. At from 1000 F to 1500 F with ordinary steels, the work softens and becomes easy to cut. At room temperature high speed steel may be above 600 Brinell hardness number. At 1200 F, the same steel will be only 300 Brinell. High temperature alloys do not soften at high temperatures and at 1500 F, frequently encountered in cutting, the hardness of the work approaches the hardness of the tool. Often, machining of high temperature materials is avoided by precision forging or grinding.

The cutting forces in machining high temperature alloys may be two to three times those of free machining steels. The rate of metal removal may be only 25% of that with normal steels. Machine rigidity and massiveness are essential. One should not try to use a bench type drill, discussers at the panel agreed.

Nearly all high temperature alloys are heat-treated. They are commonly of the austenitic or age hardening types. Parts may be heated to 2100 F and air or water quenched which softens them in the solution treated state, wherein all alloys are dissolved in a homogeneous single phase and are most easily machined.

Hardening is done by reheating to around 1600 F for about 20 hr by room temperature cooling. This process is called age hardening. Materials which must survive service temperatures of 1400 to 1500 F must be age hardened. There is a tendency to fully harden parts before machining; but this may not be the most economical method. In the solution-treated condition, higher speeds or longer tool life at the same speed can be achieved. Materials like inconel are very critical. The maximum tool life may result from a feed of 0.012 in. If this is decreased to 0.004 in. or increased to 0.016 in., the tool life may be one-third. Both the speed and feed are critical.

Lockheed has worked on machining of very hard metals and is machining without difficulty, steels such as 4130 and 6150 at tensile strength of from 220,000 to 240,000 psi. Lockheed now is developing machining techniques for materials up to 275,000 psi. In these hardness regions, high-speed steels are of very little use, and carbides are used exclusively.

In the boring, milling, and straddle milling of these steels with carbides, very rigid machines, heavy flywheels, plenty of horsepower, and backlash eliminators to permit climb milling are essential. Experiments with tapping and drilling have been unsuccessful because carbide could not be used.

Titanium—Mixed Blessing

While design engineers wax enthusiastic over the virtues of titanium, production men at the panel see the new metal giving them some hard times before they learn how to machine it. Titanium weighs only 55% as much as steel, is nearly as strong, and resists corrosion better than stainless.

It's still a pretty expensive material, the price

varying from $5 to $12 per lb. Titanium may have a tensile strength of up to 75,000 psi, but this can be increased to 175,000 psi when the material is alloyed.

What production men don't like about the material is that it can hardly be machined and is just about impossible to grind.

Metcut Research Associates was asked by the Air Force to survey the various titanium manufacturers and fabricators. This investigation disclosed that today no good production method of machining titanium exists. The ingots from remelting the sponge have casting skin containing titanium-dioxide, which is nearly as hard as silicon carbide and alumina and nearly as hard as carbide tools. It is almost impossible to machine off this porous, intensely abrasive skin. The scale may be removed by chemical methods or mechanical means such as blasting or snagging.

After removing the skin which rapidly abrades cutting edges, the material is still difficult to machine. It was thought the material had a high strain hardening capacity, but careful checking indicates it is less than stainless. Titanium is usually only 200 to 300 BHN and softens at high temperatures. The machining difficulty is still a mystery.

Drilling is a very serious problem. In grinding ordinary steel, the ratio of metal removed to wheel wear is 10 or 20 to 1. In grinding titanium, it is 1 to 1 or 1 to 20. Cutting off is very difficult with a hack saw and impossible with a band saw. The hack saw should be lifted on the return stroke. It is best to use an abrasive wheel, but plunge cutting cannot be done. Preferably an oscillating type similar to a brick cutting wheel should be used.

BASED ON PANEL DISCUSSION

Panel "Effect of Substitute versus Critical Materials in Body Design and Car Appearance," was held at SAE Annual Meeting Detroit, Jan. 14, 1951.

Materials Pinch . . .

. . . hasn't hurt car bodies yet in looks or durability. But engineers want stylists to wise up on materials situation and keep away from rococo designs in coming models so as to stretch limited materials supply.

DESPITE the tightening of materials, car bodies have suffered not at all in quality or appearance. About the only effect of government restrictions has been a slightly lowered endurance of some bright work under adverse exposure. If car bodies are to continue unaffected by materials restrictions, stylists will have to cooperate with engineers to stretch available supplies.

Three factors have combined to minimize the effect of materials shortages on car bodies:

1. Primary government Control Order M-68 limited the number of passenger vehicles that could be produced. That meant critical body materials (copper, aluminum, steel, cadmium, nickel, zinc, chromium, lead, tin, and rubber) could be allocated to fewer cars.

2. Lag in defense production over originally anticipated rate eased the pinch.

3. The government didn't feel it was necessary to impress the public with the materials scarcity by forcing unwarranted elimination of bright work, as was done at the beginning of the last war.

Coping with restrictions and substitutions and still maintaining quality of production meant that new processes and handling techniques had to be developed. Many of these changes required re-education of all personnel—from factory manager on down. Most responsible for these problems was the stringent ban on use of nickel.

When the original directive came out prohibiting use of nickel plating on nonfunctional parts, it was thought that this limitation would eliminate most bright work on cars. But availability of nickel-free stainless and development of a satisfactory process of plating chromium on a copper base allayed initial fears. These two things made it possible to continue use of bright finishes with no apparent change to the public.

If car bodies are to suffer no further austerity from materials shortages, two things will have to happen. First, designers will have to reflect in their styling the problems facing processing men. Second, the public will have to be oriented to accept plainer designs to conserve metal, and not to expect extensive decorative trim on low-volume luxury models.

Current styling trends presage more decorative metal than ever on future models. That's just what shouldn't be done if allocated amounts of critical metals are to be used wisely. Certainly those calling for designs involving deep draws, excessive recesses, and complicated polishing and buffing should be made to see the light. They should be familiar-

ized with problems of processing men, such as metals restrictions, equipment shortages, metal conditions, and excessive rejection.

The panel discussion also generated many questions on today's pressing materials situation, some of which are given here:

Q: Does a C.M.P. allotment mean you get the material?
A: No. The manufacturer must go out and purchase the material where available. The C.M.P. allotment only allows the manufacturer to use the material.

Q: If materials can be substituted successfully, why didn't we use substitutes in the first place?
A: If a material can be substituted successfully, it is almost invariably more expensive. Most substitutes that are economically feasible are less durable under adverse exposure conditions.

Q: Why can't we roll nickel free stainless on base carbon steel for such parts as bumpers?
A: The method is acceptable, but present capacities are limited and it is extremely costly to install equipment even if it would be available.

Q: Where specifically have substitute materials impaired bodies?
A: No place structurally, but as far as the finish is concerned, the durability is slightly impaired under extreme conditions.

Q: What steps have been taken to educate the public about lacquer or enamel coatings on substitute finishes?
A: Many manufacturers have placed a folder in the glove box instructing the customer not to use abrasives on enameled finishes and to wax plated parts such as the bumpers.

Q: What has been done in the way of substituting aluminum for copper in electrical systems?
A: This substitution would necessitate a long range development program, for there are a lot of problems involved, especially the one of corrosion at terminals.

Q: Why don't we substitute a 12-v for a 6-v electrical system, or even go further and use a 24-v electrical system?
A: We would materially reduce the copper used in most of the electrical components, but we would increase the amount of lead used in the battery. As voltages continue to increase, the copper savings become nil for the mechanical strength of the wire becomes the deciding factor in choosing wire diameter.

Q: Are there any other materials such as titanium that can be substituted for some of the critical materials?
A: At the present time the cost of titanium is prohibitive. The present monthly production does not even approach the needed requirements.

Q: Has the gage of the metal in bodies been reduced?
A: In general the gage has not decreased. For some selective panels, improvement in the drawing quality of the steel has permitted a reduction in the gage formerly required for fabrication. In these cases the gage formerly required was greater than the utility requirements.

Q: If we substitute steel for aluminum and copper where are we going to get the steel?
A: Wherever possible manufacturers are trying to reduce the amount of steel needed in the body. The steel so saved can then be substituted for aluminum and copper.

Beginning on page 71 . . .

complete editorial coverage of SAE National Passenger Car, Body, and Materials Meeting

New SAE Manual Simplifies

COMPUTATIONS of truck hill-climbing ability—and other calculations involving power requirements—are facilitated by a new SAE Special Publication.

The publication is SP-82 "Truck Ability Prediction Procedure," a manual prepared by the Subcommittee on Classification and Evaluation of Transportation Engineering Formulas of the Transportation and Maintenance Technical Committee.

The method of computing grade ability is based on the fact that the power available for ascending the grade is equal to the engine power output less the power consumed in overcoming rolling resistance, air resistance, and chassis friction. Truck frontal area, velocity, and altitude are taken into account in determining air resistance.

Data for all these resistances have been gathered and tabulated in the report. They will appear also in the SAE Handbook, beginning with the 1952 edition, in the SAE Recommended Practice on Truck Ability Prediction Procedure.

To facilitate computations, the committee has devised an $8\frac{1}{2} \times 11$ in. computation work sheet, which is reproduced in the manual. Copies will be available also in pads of 150 from SAE.

The tabulated data and work sheet make the job of computing vehicle grade ability simple, even for people with no engineering training. Example 1 showing the work sheet and fragments of the nine tables used indicates how straightforward the computation is.

The work sheet and tabulated data are useful also for computing:

- engine power required to propel a vehicle of given gross weight up a known grade at a given speed
- maximum speed attainable by a given vehicle on a given grade
- maximum gross weight practical in a given vehicle for a given speed and grade

EXAMPLE 1: Find the grade ability of a truck of

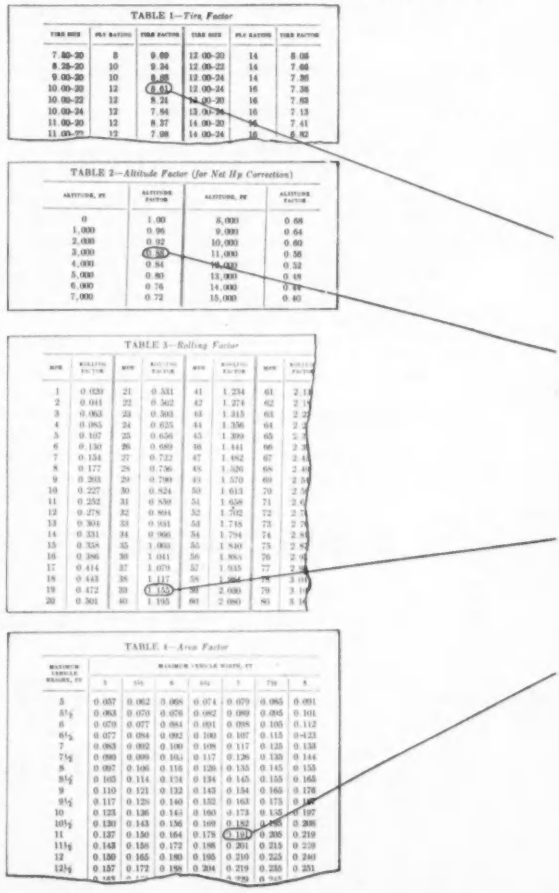


TABLE 1—*Tire Factor*

TIRE SIZE	PLY RATING	TIRE FACTOR	TIRE SIZE	PLY RATING	TIRE FACTOR
7.50-20	8	9.09	12.00-20	14	8.08
8.25-20	10	9.34	12.00-22	14	7.96
9.00-20	10	8.98	12.00-24	14	7.86
10.00-20	12	8.61	12.00-24	16	7.38
10.00-22	12	8.24	13.00-20	16	7.83
10.00-24	12	7.84	13.00-24	16	7.13
11.00-20	12	8.37	14.00-20	16	7.41
11.00-22	12	7.98	14.00-24	16	6.82

TABLE 2—*Altitude Factor (for Net Hp Correction)*

ALTITUDE, FT	ALTITUDE FACTOR	ALTITUDE, FT	ALTITUDE FACTOR
0	1.00	8,000	0.68
1,000	0.96	9,000	0.64
2,000	0.92	10,000	0.60
3,000	0.88	11,000	0.56
4,000	0.84	12,000	0.52
5,000	0.80	13,000	0.48
6,000	0.76	14,000	0.44
7,000	0.72	15,000	0.40

TABLE 3—*Rolling Factor*

MPH	ROLLING FACTOR	MPH	ROLLING FACTOR	MPH	ROLLING FACTOR	MPH	ROLLING FACTOR
1	0.020	21	0.531	41	1.234	61	2.138
2	0.041	22	0.562	42	1.274	62	2.194
3	0.063	23	0.593	43	1.315	63	2.250
4	0.085	24	0.625	44	1.356	64	2.306
5	0.107	25	0.656	45	1.399	65	2.363
6	0.130	26	0.689	46	1.441	66	2.420
7	0.154	27	0.722	47	1.482	67	2.478
8	0.177	28	0.756	48	1.526	68	2.536
9	0.201	29	0.790	49	1.570	69	2.594
10	0.227	30	0.824	50	1.613	70	2.653
11	0.252	31	0.859	51	1.658	71	2.712
12	0.278	32	0.894	52	1.702	72	2.771
13	0.304	33	0.931	53	1.748	73	2.831
14	0.331	34	0.966	54	1.794	74	2.891
15	0.358	35	1.003	55	1.840	75	2.952
16	0.386	36	1.041	56	1.886	76	3.013
17	0.414	37	1.079	57	1.935	77	3.074
18	0.443	38	1.117	58	1.984	78	3.135
19	0.472	39	1.155	59	2.033	79	3.197
20	0.501	40	1.195	60	2.080	80	3.259

TABLE 4—*Area Factor*

MAXIMUM VEHICLE HEIGHT, FT	MAXIMUM VEHICLE WIDTH, FT						
	5	5½	6	6½	7	7½	8
5	0.057	0.062	0.068	0.074	0.079	0.085	0.091
5½	0.063	0.070	0.076	0.082	0.089	0.095	0.101
6	0.070	0.077	0.084	0.091	0.098	0.105	0.112
6½	0.077	0.084	0.092	0.100	0.107	0.115	0.123
7	0.083	0.092	0.100	0.109	0.117	0.125	0.133
7½	0.089	0.099	0.108	0.117	0.126	0.135	0.144
8	0.097	0.106	0.116	0.126	0.135	0.145	0.155
8½	0.103	0.114	0.124	0.134	0.145	0.155	0.165
9	0.110	0.121	0.132	0.143	0.154	0.166	0.176
9½	0.117	0.128	0.140	0.152	0.163	0.175	0.187
10	0.123	0.136	0.148	0.160	0.173	0.185	0.197
10½	0.130	0.143	0.156	0.169	0.182	0.195	0.208
11	0.137	0.150	0.164	0.178	0.190	0.205	0.219
11½	0.143	0.158	0.172	0.186	0.201	0.215	0.229
12	0.150	0.165	0.180	0.195	0.210	0.225	0.240
12½	0.157	0.172	0.188	0.204	0.219	0.235	0.251

MEMBERS of the Subcommittee on Classification and Evaluation of Transportation Engineering Formulas, which prepared the Truck Ability Prediction Procedure, are:

F. B. Lautzenhiser, Chairman

M. C. Alves
Robert Cass
S. Colacuori
Linn Edsall
F. L. Faulkner
Julius Gaussoin
F. K. Glynn
E. P. Gohn
William Harrigan
E. N. Hatch
M. C. Horine
V. C. Kloepper
E. P. Lamb
L. G. Lundstrom
E. L. Mench, Jr.
M. E. Nuttila
J. G. Oetzel
W. C. Parker
Bart Rawson
H. L. Rittenhouse
Carl Saal
J. L. S. Snead, Jr.
G. M. Sprowls
A. F. Stamm
Hoy Stevens
W. A. Taussig
Walter E. Turner
H. L. Willett, Jr.

Editorial Group

M. C. Horine Henry Jennings M. E. Nuttila

Computations of Truck Ability

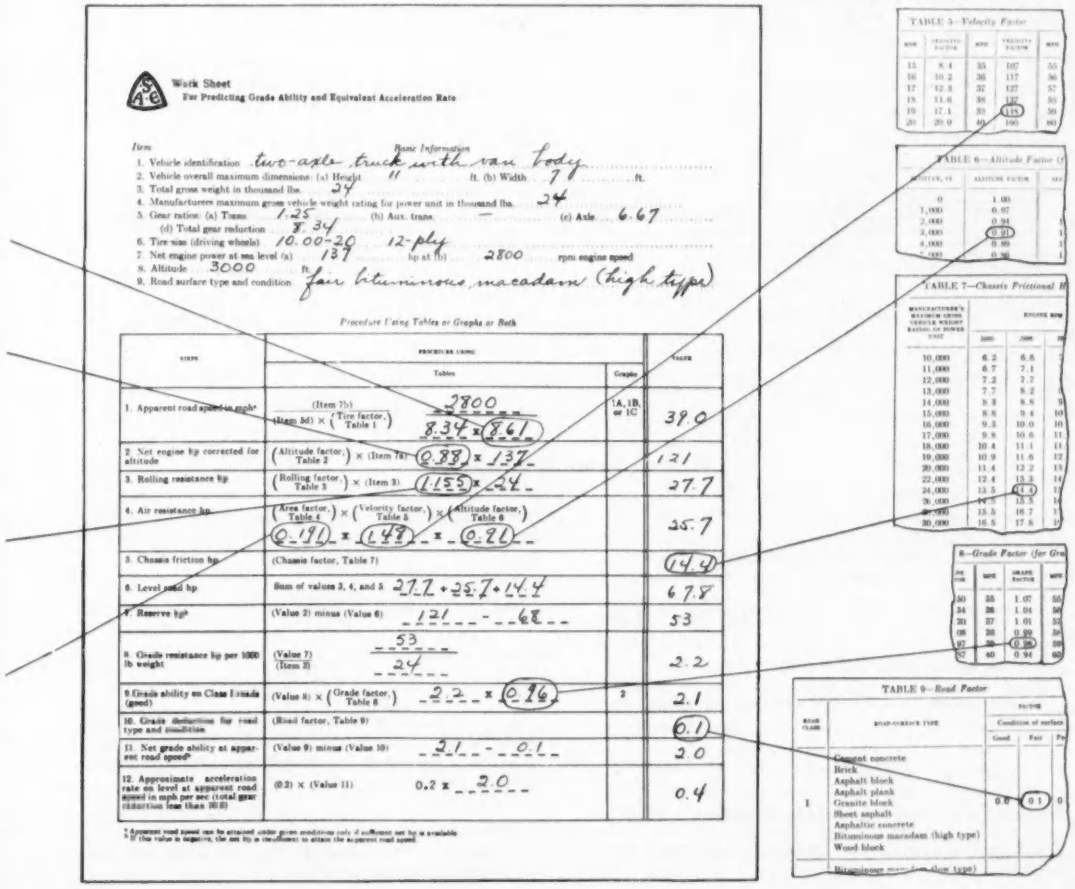
- effect on grade ability of changes in overall vehicle dimensions
- best gear ratio for a given vehicle and operating conditions

Example 2 follows an example given in the manual of how to calculate engine power required in a given truck under known operating conditions. This is the kind of problem that might confront an operator who had a truck in mind for his operation and wanted to select an engine for it from several available 2800-rpm engines. The example assumes the critical combination of grade and speed is a 3% grade at 39 mph (for convenience, the grade and speed conditions calculated in Example 1).

The computation involves a cut-and-try solution. In Example 2, the first two trial values of altitude horsepower, 135 and 165 hp, happen not to give the desired grade ability, but they do bracket the desired value. Interpolation suggests a trial altitude power of 150 hp, which does yield the desired grade ability. This altitude power divided by the altitude factor gives a value of 176 hp required at sea level.

If the operator has a choice of a 130-hp engine, a 150-hp engine, and a 200-hp engine, he could ex-

known characteristics operating over high-type bituminous macadam in fair condition at 3000 ft altitude



Work Sheet
For Predicting Grade Ability and Equivalent Acceleration Rate

Item — Basic Information

1. Vehicle identification: two-axle truck with van body
2. Vehicle overall maximum dimensions: (a) Height 11 ft. (b) Width 7 ft.
3. Total gross weight in thousand lbs. 24
4. Manufacturers maximum gross vehicle weight rating for power unit in thousand lbs. 24
5. Gear ration: (a) Trans. 1.25 (b) Aux. trans. — (c) Axle 6.67 (d) Total gear reduction 8.34
6. Tire size (driving wheels) 10.00-20 12-ply
7. Net engine power at sea level (a) 137 hp at (b) 2800 rpm engine speed
8. Altitude 3000 ft.
9. Road surface type and condition: fair bituminous macadam (high type)

Procedure Using Tables or Graphs or Both

Steps	Procedure Using: Tables	Graphs	Value
1. Apparent road speed in mph*	(Item 7b) / (Item 5d) × (Tire factor, Table 1) = 2800 / 8.34 × 8.61	1A, 1B, or 1C	39.0
2. Net engine hp corrected for altitude	(Altitude factor, Table 2) × (Item 7a): 0.88 × 137		121
3. Rolling resistance hp	(Rolling factor, Table 3) × (Item 3): 1.155 × 24		27.7
4. Air resistance hp	(Area factor, Table 4) × (Velocity factor, Table 5) × (Altitude factor, Table 6): 0.191 × 148 × 0.91		25.7
5. Chassis friction hp	(Chassis factor, Table 7)		14.4
6. Level road hp	Sum of values 3, 4, and 5: 27.7 + 25.7 + 14.4		67.8
7. Reserve hp*	(Value 2) minus (Value 6): 121 − 68		53
8. Grade resistance hp per 1000 lb weight	(Value 7) / (Item 3): 53 / 24		2.2
9. Grade ability on Class I roads (good)	(Value 8) × (Grade factor, Table 8): 2.2 × 0.96	2	2.1
10. Grade deductions for road type and condition	(Road factor, Table 9)		0.1
11. Net grade ability at apparent road speed*	(Value 9) minus (Value 10): 2.1 − 0.1		2.0
12. Approximate acceleration rate on level at apparent road speed in mph per sec (total gear reduction less than 30:1)	(0.2) × (Value 11): 0.2 × 2.0		0.4

* Apparent road speed can be attained under given conditions only if sufficient net hp is available.
† If this value is negative, the net hp is insufficient to attain the apparent road speed.

TABLE 5—*Velocity Factor*

MPH	VELOCITY FACTOR	MPH	VELOCITY FACTOR	MPH
15	8.4	35	107	55
16	10.2	36	117	56
17	12.3	37	127	57
18	14.6	38	137	58
19	17.1	39	148	59
20	20.0	40	160	60

TABLE 6—*Altitude Factor (A*

ALTITUDE, FT	ALTITUDE FACTOR	MPH
0	1.00	
1,000	0.97	
2,000	0.94	
3,000	0.91	
4,000	0.88	
5,000	0.86	

TABLE 7—*Chassis Frictional H*

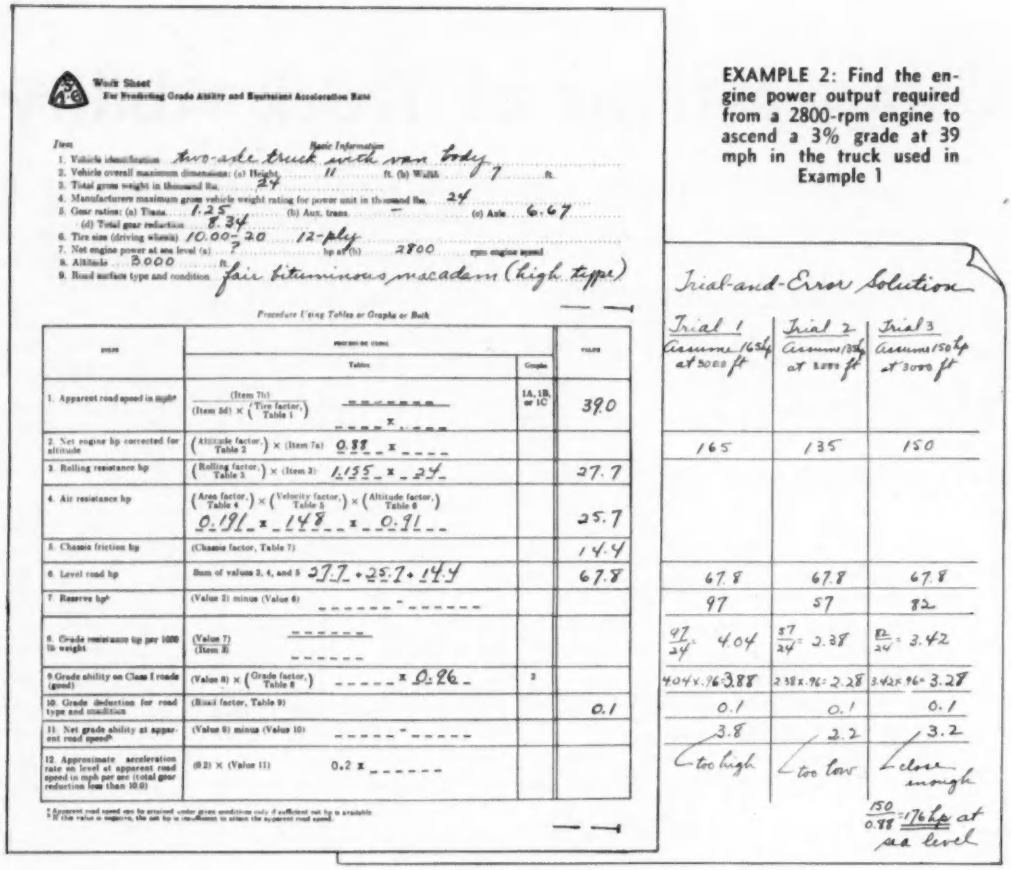
MANUFACTURER'S MAXIMUM GROSS VEHICLE WEIGHT RATING OR POWER UNIT	ENGINE RPM		
	2600	2800	3
10,000	6.2	6.6	
11,000	6.7	7.1	
12,000	7.2	7.7	
13,000	7.7	8.2	
14,000	8.3	8.8	9
15,000	8.8	9.4	10
16,000	9.3	10.0	10
17,000	9.8	10.6	11
18,000	10.4	11.1	11
19,000	10.9	11.6	12
20,000	11.4	12.2	13
22,000	12.4	13.2	14
24,000	13.5	14.4	15
26,000	14.5	15.5	16
28,000	15.5	16.7	17
30,000	16.5	17.8	19

8—*Grade Factor (for Gra*

PE CEN	MPH	GRADE FACTOR	MPH
50	33	1.07	55
34	38	1.04	56
30	37	1.01	57
08	36	0.99	58
97	35	0.96	59
92	60	0.94	60

TABLE 9—*Road Factor*

ROAD CLASS	ROAD-SURFACE TYPE	FACTOR: Condition of surface: Good	Fair	Fa
I	Cement concrete			
	Brick			
	Asphalt block			
	Asphalt plank			
	Granite block	0.0	0.1	0
	Sheet asphalt			
	Asphaltic concrete			
	Bituminous macadam (high type)			
	Wood block			
	Bituminous macadam (low type)			



Work Sheet
For Predicting Grade Ability and Equivalent Acceleration Rate

Item — Basic Information

1. Vehicle identification: two-axle truck with van body
2. Vehicle overall maximum dimensions: (a) Height ... ft. (b) Width 11 ft. (c) Length 7 ft.
3. Total gross weight in thousand lbs: 24
4. Manufacturers maximum gross vehicle weight rating for power unit in thousand lbs: 24
5. Gear ratios: (a) Trans. 1.25 (b) Aux. trans. — (c) Axle 6.67 (d) Total gear reduction 8.34
6. Tire size (driving wheels) 10.00-20 12-ply
7. Net engine power at sea level (a) ? hp at (b) 2800 rpm engine speed
8. Altitude 3000 ft.
9. Road surface type and condition: fair bituminous macadam (high type)

Procedure Using Tables or Graphs or Both

Item	Procedure — Tables	Procedure — Graphs	Value
1. Apparent road speed in mph*	(Item 7b) / (Item 6d) × (Tire factor, Table 1) = ____ × ____	1A, 1B, or 1C	39.0
2. Net engine hp corrected for altitude	(Altitude factor, Table 2) × (Item 7a): 0.88 × ____		
3. Rolling resistance hp	(Rolling factor, Table 3) × (Item 2): 1.155 × 24		27.7
4. Air resistance hp	(Area factor, Table 4) × (Velocity factor, Table 5) × (Altitude factor, Table 6): 0.191 × 148 × 0.91		25.7
5. Chassis friction hp	(Chassis factor, Table 7)		14.4
6. Level road hp	Sum of values 3, 4, and 5: 27.7 + 25.7 + 14.4		67.8
7. Reserve hp†	(Value 2) minus (Value 6) ____ − ____		
8. Grade resistance hp per 1000 lb weight	(Value 7) / (Item 2) ____ / ____		
9. Grade ability on Class I roads (good)	(Value 8) × (Grade factor, Table 8) ____ × 0.96	2	
10. Grade deduction for road type and condition	(Road factor, Table 9)		0.1
11. Net grade ability at apparent road speed*	(Value 9) minus (Value 10) ____ − ____		
12. Approximate acceleration rate on level at apparent road speed in mph per sec (total gear reduction less than 10.0)	(0.2) × (Value 11): 0.2 × ____		

* Apparent road speed can be attained under given conditions only if sufficient net hp is available.
† If the value is negative, the net hp is insufficient to attain the apparent road speed.

EXAMPLE 2: Find the engine power output required from a 2800-rpm engine to ascend a 3% grade at 39 mph in the truck used in Example 1

Trial-and-Error Solution

Trial 1	Trial 2	Trial 3
Assume 165 hp at 3000 ft	Assume 135 hp at 3000 ft	Assume 150 hp at 3000 ft
165	135	150
67.8	67.8	67.8
97	57	82
97/24 = 4.04	57/24 = 2.38	82/24 = 3.42
4.04 × .96 = 3.88	2.38 × .96 = 2.28	3.42 × .96 = 3.28
0.1	0.1	0.1
3.8	2.2	3.2
too high	too low	close enough

150/0.88 = 176 hp at sea level

Procedure for Solving Example 2

- Enter road speed in Step 1.
- Compute resistance and friction horsepowers according to Steps 3, 4, and 5.
- Compute level-road horsepower according to Step 6.
- Enter grade factor in Step 9.
- Enter grade deduction for road type and condition according to Step 10.

The next three steps constitute a cut-and-try solution:

- Assume a net engine horsepower corrected for altitude and enter for Step 2.
- Subtract level road horsepower from net engine horsepower according to Step 7 to get reserve horsepower.
- Carry out Steps 8, 9, and 11.
- If calculated grade ability does not match required grade ability, assume another value for net engine horsepower corrected for altitude and repeat the cut-and-try part of this solution.
- Divide the final value of net horsepower corrected for altitude by the altitude factor from Table 2 to get net engine power at sea level.

pect that the 200-hp engine will be adequate and that the other two won't be.

To check the validity of the data and methods, computed values have been checked against results of road tests. Figs. 9, 10, and 11 of the manual compare computed maximum speeds for various grades with speeds actually attained by the trucks on the road. Except for the level section, there appears to be fairly close agreement.

For any computations using the data in the manual, differences between computed and actual values stem from two sources: inaccuracies in the data and the fact that the data are averages for a range of vehicles and operating conditions. The committee recognizes that it may be necessary in the future to revise the tables as more reliable data on resistances become available. But they warn that, as long as the data represent ranges of vehicles and conditions, perfect agreement between computed and road-test results should not be expected.

In addition to the data and facsimile forms, the manual contains sections on the method and its reliability, a detailed discussion of the grade ability example worked in this article, and explanations of the other types of computations for which the data are useful.

The report does not include complete derivations of the formulas used to work test results into the tabulated resistance data because the derivations are already available in three SAE papers published in SAE Quarterly Transactions:

"An Evaluation of Factors Used to Compute Truck Performance" by Carl C. Saal in Vol. 3, No. 2, April 1949, pp. 215–228 of SAE Quarterly Transactions.

"Predicting Road Performance of Commercial Vehicles" by A. F. Stamm and E. P. Lamb in Vol. 4, No. 2, April 1950, pp. 147–160 of SAE Quarterly Transactions.

"Truck Road Performance—Actual vs. Computed" by Carl Saal in Vol. 5, No.1, January 1951, pp. 18–25, 93 of SAE Quarterly Transactions.

The manual, SP-82, is available from the SAE Special Publications Department (29 West 39 St., New York 18) at $1.50 to SAE members and $3.00 to nonmembers. Work sheets are available in pads of 150 for $2.00 per pad to members and $4.00 per pad to nonmembers. One copy of the SAE Commercial Vehicle Ability Report is supplied with each pad. Additional copies are priced at 25¢ each for 2 to 9 copies, 10¢ each for 10 to 49 copies, 5¢ each for 50 to 99 copies, and 2¢ each for 100 or more copies. Manual and forms are copyright, but permission may be obtained from the Society to reproduce the forms.

BASED ON PAPER BY **Major-Gen. Francis H. Griswold, USAF**

Munitions Board

Materials Stockpile . . .

. . . not just for military. It's being built up as a reserve for civilian production too in case of war. Stockpile right now at only about one-third of estimated needs for full-scale hostilities.

THE stockpile is the reserve of selected materials designed to make up the deficit between probable supplies and estimated total needs during an all-out war. It is national scope, not just military. It will provide the industrial and essential civilian wartime needs as well as those of a direct military nature.

Stockpile objectives are determined by the Interdepartmental Stockpile Committee, composed of representatives from more than a score of boards, departments and commissions. This committee considers requirements and supply data for each material and recommends stockpile objectives to be formally established by the Munitions Board and Secretary of the Interior.

Actual purchases for the stockpile are conducted by the General Services Administration at the direction of the Munitions Board and with the assistance of other agencies. The present rate of acquisition, although in most cases below the targets set by the Munitions Board, is governed by the determination of the civilian agencies. The Defense Production Administration is the key control agency. It coordinates the activities of the other agencies and has the responsibility for determining the current and long-range requirements for strategic and critical materials.

Congress has authorized a grand total of $5 billion for stockpiling purposes. As of Aug. 31, 1951 we had on hand $3.2 billion worth of materials against an overall objective of $8.7 billion, which means that we have on hand 36% of the total quantities of stockpile materials we would need to fight a major war. We are making progress, but we have a long way to go. (Paper "The Munitions Board in National Defense" was presented at SAE Annual Meeting, Detroit, Jan. 15, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

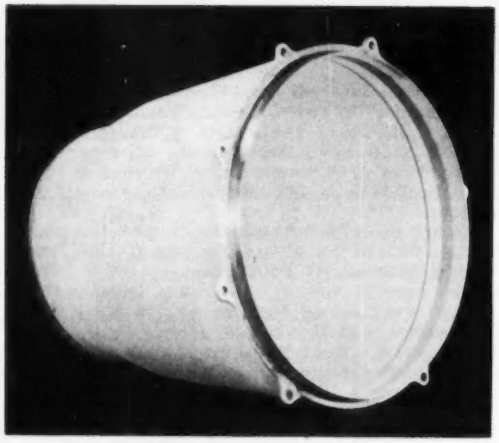


Fig. 1—Burner outer casing, aluminized

Trends in Gas

STRATEGICALLY important metals are the key to jet engine performance; if large numbers of jet engines are to be built, these metals must therefore be utilized as efficiently as possible.

There are several possible methods of approach to the problem. Two of them are:

1. Substitution of protectively coated carbon or low-alloy steels for stainless alloys in parts which operate at relatively low temperature.

2. Development of less critical super-alloys having high-temperature properties equal or superior to those of existing alloys.

Success in some applications of each of these methods may of course be impossible without redesign of engine components.

In general, if stresses are high and if temperatures encountered are much in excess of 1000 F, the austenitic chromium-nickel type alloys must be specified. For lower temperatures, choice between ferritic stainless steels and low-alloy steels is often dictated by creep values and requirements of corrosion resistance. Where the necessary corrosion resistance can be maintained under operating conditions by application of protective coatings, it is frequently possible to conserve appreciable quantities of chromium by specifying plain carbon or low-alloy steels. Attempts are being made to develop protective coatings which will make it possible to use heat-treatable carbon and low-alloy steels for all steel parts of jet engines which get no hotter than 900 or 1000 F.

For non-rotating parts not subject to abrasion, such as brackets and internal supporting components, ample corrosion resistance is afforded by certain silicone-vehicle aluminum paints, provided temperatures do not exceed 400 or 500 F.

Where abrasion and other mechanical abuse are factors, excellent corrosion resistance can be obtained by application of sprayed aluminum, provided the thick coating does not adversely affect performance and temperatures do not exceed approximately 600 F. An aluminized outer burner casing formed of AMS 5040 (SAE 1010) steel (Fig. 1) is an example of an advantageous use of this type of coating. Many thousands of similar aluminized burner casings are in service, and their performance has been excellent.

For protection of rotating parts where close dimensional tolerances must be maintained, cadmium plating can be successfully employed provided maximum operating temperatures are below the melting point of cadmium. The problem of protection of similar parts operating at temperatures above the melting point of cadmium is complicated by the fact that otherwise desirable metal plates, such as chromium and nickel, may seriously reduce the effective fatigue strength of the metal. Furthermore, it is virtually impossible to electroplate uniform thicknesses over surfaces of complicated parts. Because of relative uniformity of the deposited coating, electroless nickel plate holds considerable promise, although effects of this coating on fatigue endurance are not as yet known.

Where high resistance to corrosion, erosion, and abrasion must be maintained in parts which may operate at temperatures up to 1000 F, use of ferritic stainless steels seems mandatory. Such parts include axial-flow compressor blades, bolts, shafts, and turbine discs. For these applications, it appears that, in addition to the creep problem, consideration must be given to selecting the stainless grade least subject to stress-corrosion cracking.

A failure of an experimental tie bolt of AMS 5615 (AISI Type 414) stainless steel was found to have resulted from stress corrosion, the corroding medium being water. Since rust stains from an adjacent plain-carbon steel part were found on the

Turbine Engine Materials

EXCERPTS FROM PAPER BY

R. H. Thielemann, Development Metallurgist
J. C. Mertz, Materials Engineer
W. P. Eddy, Jr. Chief, Engineering Operations
Pratt and Whitney Aircraft Division of United Aircraft Corporation

• Paper "Trends in Gas Turbine Engine Materials" was presented at the SAE Annual Meeting, Detroit, January 15, 1952.

tie bolt, it was believed that galvanic action might have been involved.

The investigation developed into a series of stress corrosion tests, about 125 of which have to date been conducted under laboratory-controlled conditions, using materials having nominal compositions as shown in Table 1. Several of the tests were conducted with iron wires wrapped around the test bars, to determine effects of galvanic action. A few tests with other dissimilar metals in contact with test bars were also run. All tests were on polished ASTM E8 tensile test bars, accurately stressed in loading fixtures, and exposed to ASTM B117 salt spray or JAN-H-792 humidity, salt spray being used for most of the tests. Tests of bars which did not fail after 50 days of exposure were discontinued.

Because of inevitable scatter in duplicate tests of this nature, it will not be possible to report specific results until many additional tests have been completed. Nevertheless, the following conclusions can

Table 1—Alloys Tested in Stress Corrosion Program

Specification	Type*	Nominal Composition, %				
		C	Cr	Ni	Mo	Other
AMS 5615	414	0.12	12.5	1.8		
AMS 5610	416	0.12	12.5	0.4	0.5	
AMS 5613	410	0.12	12.5	0.5	0.3	Se or S 0.27
AMS 5616		0.15	13.0	2.0	0.4	W 3.0
AMS 5628	431	0.16	16.0	2.2		
AMS 5632	440F	1.10	17.4		0.5	Se 0.15
	422Sp	0.20	13.5	0.5	1.0	W 1.0, V 0.2
AMS 5637	302	0.10	18.0	9.0		Mn 1.5
PWA 675	Ni-Base	0.05	20.0	59.0	3.0	Co 13.5, Ti 2.5, Al 1.2
	Ti-Base	0.20				Mn 4.0, Al 4.0, Ti 91.0
AMS 5024	1137	0.36				Mn 1.5
AMS 5132	1095	1.00				
AMS 6322	8740	0.40	0.5	0.5	0.2	
AMS 6415	4340	0.40	0.8	1.8	0.2	
AMS 6448	6150	0.52	0.9			V 0.1
	Cr-Mo-V	0.40	1.0		0.6	V 0.3
	H40	0.25	2.9	0.2	0.5	W 0.5, V 0.8

* All alloys, except two indicated, are steels.

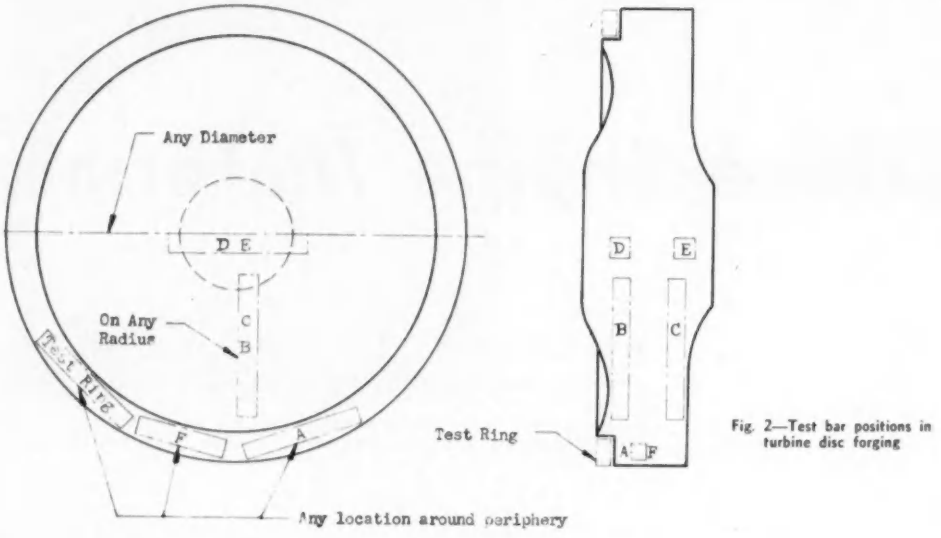


Fig. 2—Test bar positions in turbine disc forging

tentatively be drawn from results thus far:

(a) Iron and other dissimilar metals in contact with test bars produced little if any effect on times of failure.

(b) AMS 5615 (Type 414) stainless steel proved to be susceptible to failure by stress-corrosion cracking even with fairly low values of stress.

(c) In the hardness range of Rockwell C30-40, AMS 5616 appears to be least susceptible of the seven ferritic stainless steels tested, although additional tests at lower stress levels will be necessary before definite conclusions can be drawn.

(d) Cold-drawn AMS 5637 (Type 302) austenitic steel, the PWA 675 (Waspaloy) nickel-base heat-resistant alloy, and the titanium alloy do not appear to be sensitive to stress-corrosion conditions.

(e) No failures have as yet been experienced with Rockwell C30-40 heat-treated plain carbon or low-alloy steels.

(f) At hardness of Rockwell C50 and with stress of 160,000 psi, AMS 6448 (SAE 6150) steel failed in several tests.

(g) At hardness of Rockwell C40 and with stress of 160,000 psi, Cr-Mo-V high-temperature bolting steel failed.

(h) Superiority of AMS 6415 (SAE 4340) and AMS 6322 (SAE 8740) steels over the ferritic stainless steels, under the conditions used, has been clearly shown.

The compressor sections of turbine engines contain many parts which, in service, are both highly stressed and subjected to corrosive salt and moisture. Materials used in such parts must obviously not be those which may fail prematurely from stress corrosion. Fortunately, from the conservation standpoint, relative stress-corrosion-resisting properties appear to point the way to using less of certain strategic elements. Possibilities of such savings are in compressor discs, shafts, bolts, and spacers.

High-Temperature Alloy Developments

Since burner liners, transition ducts, nozzle guide vanes, turbine blades, turbine discs, and exhaust tail cones of turbine engines must operate at high temperatures, refractory alloys must be specified. Although these parts in present production engines are being made of high-temperature alloys which were developed five to ten years or more ago, present indications are that it may soon be possible to substitute some of the less strategic alloys recently developed.

Burner liners, transition ducts, and parts of exhaust tail cones in a turbine engine are subjected to gas temperatures ranging from 1200 F to as high as 1800 F. Thermal stresses developed from high thermal gradients tend to produce buckling and eventual cracking. Materials which in sheet form have enjoyed the widest use for these parts are two nickel-base alloys, one of which is covered by AMS 5540. Except for their somewhat lower thermal expansion coefficients, important properties of these

two alloys are comparable to those of AMS 5521 (Type 310) austenitic steel, which has also been used for these applications. Since low thermal expansion is important in minimizing thermal stresses, any new alloy developed for these applications should have at least as low expansion coefficient as have these nickel-base alloys in order to replace them on an equal performance basis. Compositions and stress-rupture properties at 1800 F of the three alloys mentioned above and of a new iron-base alloy which is now under test are shown in Table 2; all have low carbon and usual manganese and silicon contents. If the new alloy proves satisfactory, considerable savings in nickel can be realized by its use in hot-operating sheet metal parts of turbine engines.

Turbine nozzle guide vanes are subjected to very severe temperature gradients. Since turbine performance is adversely affected if nozzle throat area changes during operation, only alloys which have high creep strength at temperatures of 1600 F or higher can be considered. Since nozzle vane cross-sections are airfoils, it is desirable to make them hollow and of uniform wall thickness so that thermal stresses will be minimized. Because of their shapes, hollow nozzle guide vanes are very difficult to fabricate from high-strength heat-resistant alloys. Therefore, precision investment castings are universally used, and cobalt-base alloys are specified. Properties of the best of these cobalt-base alloys are not all that is desired for the nozzle guide vane application; for this reason development of satisfactory less critical compositions has been most difficult. Material conservation would not be realized if several sets of replacement guide vanes made of a lower-alloy composition had to be furnished in place of one set of the present cobalt-base alloy vanes. Nevertheless, much development work has been done in attempts to produce a reduced-cobalt-content alloy having properties adequate for these applications. The presently used alloy, AMS 5385, and the three most promising substitute alloys we have seen to date are outlined in Table 3; nominal carbon contents are between 0.27 and 0.45%, and silicons between 0.50 and 0.75%. The three new casting alloys, which are similar to one another in composition, have been evaluated in laboratory creep and thermal-shock tests and are currently being tested in engines. Use of any of them for nozzle guide vanes in place of the present high-cobalt alloy would bring about an appreciable reduction in overall jet engine requirements for cobalt, though increasing requirements for nickel and tungsten.

As far as turbine discs are concerned, the problem for the metallurgist has been to develop melting, forging, and heat-treating procedures which will produce sound discs having uniform properties in all sections. Until reliable disc-cooling techniques are developed, so that temperatures at rims of turbine discs do not exceed 1000 F, use of ferritic steel turbine discs to conserve critical alloying elements will not be feasible. Requirements for turbine discs in current jet engines are that rims of discs shall have high load-carrying abilities up to temperature of 1200 F and that room-temperature yield strength in hub sections of discs shall be not less than 75,000 psi. Reasonable ductility must be available in all

Table 2—Refractory Sheet Materials

Material	Nominal Composition, %				Mean Thermal Expansion Coefficient from 70-1800 F, per deg F × 10 ^{6}	Average Stress for Failure at 1800 F, psi	
	Cr	Ni	Ti	Fe		10 hr	100 hr
AMS 5540	15	74	—	8	9.4	4000	2500
PWA 673	20	77	0.4	—	9.0	3900	2350
AMS 5521	25	20	—	53	10.4	5150	2850
Iron Alloy	20	35	1.0	42	9.4	3900	2400

Table 3—Nozzle Guide Vane Alloys

Material	Nominal Composition, %						Mechanical Properties (Typical)				
							At Room Temperature			20,000 psi Rupture at 1500 F	
	Mn	Cr	Ni	Mo	W	Co	Yield Strength (0.2%), psi	Ultimate Strength, psi	Elongation, % in 2 in.	Time (hr)	Elongation, % in 2 in.
AMS 5385	0.7	27	3	6	—	62	80,000	100,000	8.0	130	10
Alloy A	0.7	26	42	8	6	14	63,500	75,200	3.0	120	15
Alloy B	2.5	25	47	3	7	12	67,000	79,000	5.0	110	25
Alloy C[a]	1.5	25	30	4	6	20	65,000	82,000	6.0	125	13

[a] Also Nitrogen 0.20%

Table 4—Heat-Treatable Turbine Disc Alloys

Material	Nominal Composition, %									
	C	Mn	Si	Cr	Ni	Mo	Ti	Al	V	Fe
PWA 746	0.05	1.0	0.5	15.0	26.0	3.0	1.7	0.2	—	52.0
PWA 747	0.05	1.5	0.8	15.0	26.0	1.5	2.0	0.2	0.4	52.0

Test Bar Position in Disc Forging	Typical Room-Temperature Mechanical Properties					
	PWA 746			PWA 747		
	0.2% Yield Strength, psi	Ultimate Strength, psi	Elongation, % in 2 in.	0.2% Yield Strength, psi	Ultimate Strength, psi	Elongation, % in 2 in.
Test Ring	91,500	132,000	21.6	120,800	158,500	21.0
A	92,500	133,750	24.5	122,500	159,000	22.5
B	87,000	134,250	21.0	119,000	157,000	21.5
C	105,000	140,250	26.0	115,500	155,500	21.0
D	79,500	118,250	21.5	107,500	147,750	20.0
E	92,500	130,500	18.5	110,000	142,750	11.5

Test Bar	Test Bar Position in Disc Forging	Typical High-Temperature Stress-Rupture Properties			
		Stress, psi	Temperature, F	Time for Failure, hr	
				PWA 746	PWA 747
Notched bar, 60 deg. V 0.005 in. radius	F	60,000	1200	32.0	252.9
Plain bar	F	42,500	1300	24.2	207.0

Table 5—Turbine Blade Alloys

	AMS 5765	AMS 5382	PWA 675 (Waspaloy)
Nominal Composition, %			
Carbon	0.40	0.50	0.07
Chromium	20.5	25.5	19.5
Nickel	20.5	10.5	59
Cobalt	45	55	13.5
Molybdenum	4	....	3
Tungsten	4	7.5	....
Columbium	4	....	....
Titanium	....	....	2.5
Aluminum	....	....	1.2
Heat-Treatment			
Solution	2150 F, 1 hr, water quench	None	1950 F, 4 hr oil quench
Precipitation	1400 F, 16 hr air cool	None	1375 F, 16 hr air cool
Room-Temperature Properties, Average			
Ultimate Strength, psi	139,750	113,000	165,000
Yield Strength (0.2% offset), psi	67,000	79,500	97,500
Elongation, %	35	8	40
Reduction of Area, %	29	9	35
Hardness, Bhn	280	325	300
High-Temperature Stress-Rupture Properties (Average) psi			
100 hr at 1350 F	40,000	42,000	52,500
300 hr at 1350 F	35,000	38,000	47,500
100 hr at 1500 F	25,000	28,700	27,500
300 hr at 1500 F	22,500	26,000	22,500
100 hr at 1600 F	14,000	21,000	16,500
300 hr at 1600 F	11,500	19,000	14,000

sections of discs, so that stress concentrations resulting from design configurations or metallurgical defects can be relieved without cracking. In small discs these requirements are not difficult to meet. But as discs get larger the problem of melting large ingots of heat-resisting alloys and forging them into sound turbine discs becomes increasingly difficult. Further, since most austenitic heat-resisting alloys require finish-forging at temperatures below recrystallization ranges in order to cold-work the material sufficiently to meet the high yield strength requirements, the forging problem increases greatly with increased disc size. For large turbine discs, the best solution to the problem seems to be the composite disc design in which a cold-worked austenitic alloy rim is welded to a heat-treatable low-alloy steel hub. By this construction, desirable properties of each type of material are efficiently utilized and appreciable savings in critical alloys are realized. However, if cost of producing two forgings instead of one and overall use of critical materials in two forgings and the weld wire are taken into account, the one-piece austenitic alloy disc forging appears more attractive for discs smaller than 18 or 20 in. in diameter.

For the one-piece austenitic alloy disc forging, desire for an alloy in which needed properties could be developed by heat-treatment instead of by cold-working has always existed. Advantages of such an alloy are that properties would be easier to control and that the large forging equipment now needed to do cold-working would not be necessary. In recent years, two similar alloys of the titanium-bearing precipitation-hardening type have been developed, and both have been made in production quantities.

Turbine discs of both alloys have been fully tested in engines with generally excellent results. Both alloys have properties which make them attractive also for applications other than turbine discs, such as bolts, flanges, and turbine blades which run at temperatures not higher than about 1100 F.

Positions in turbine disc forgings from which test coupons are regularly cut for test are indicated in Fig. 2. Compositions and properties of disc forgings made of these two alloys are shown in Table 4. The PWA 746 alloy forging was made from ingot produced by the Kellogg Electric Ingot Process, whereas the PWA 747 alloy forging was made from conventional ingot. Although the PWA 747 discs have somewhat higher properties, either material in disc form has adequate properties to meet turbine disc requirements of some engines.

Turbine blade requirements for a modern high-thrust turbojet engine are for a material with high load-carrying ability at temperatures of 1500 F and higher. In 10 years of experience with jet engines in this country, two cobalt-base alloys have been developed which appear to meet these requirements —AMS 5765 forging alloy and AMS 5382 casting alloy. As considerable satisfactory experience has been obtained with both of these alloys, they are currently being specified for turbine blades in several production jet engines. Since both alloys contain large proportions of critical alloying elements, their continued use for turbine engine blading in a greatly expanded jet engine program might well be a limiting factor with respect to the number of jet engines produced.

Being cognizant of the serious critical material shortage which might develop with regard to turbine blades, engine builders and alloy producers have carried on extensive research programs to develop less critical turbine blading alloys which would meet requirements. Most of the effort is being directed to develop a nickel-base precipitation-hardening alloy similar but superior to the series of alloys which have enjoyed such wide use in British jet engines. The specific problem is to develop a balanced-composition alloy which will have the required properties and which can be made in reasonable production quantities. Several promising compositions have been forthcoming from this effort. One of these is the nickel-base Waspaloy which PWA is currently developing for turbine blades in advanced turbojet engines. Nominal compositions and typical properties of AMS 5765, AMS 5382, and Waspaloy are shown in Table 5.

Replacing stainless alloys with protectively coated carbon or low-alloy steels, and developing superalloys having lower strategic metal content are not the only ways to reduce amounts of strategic metals required for turbine engines. Aircraft engine manufacturers are also developing manufacturing processes that utilize materials more efficiently and redesigning engine components to be made of lower-alloy metals.

Of course, there are problems encountered with each method, but the problems do not appear impossible to solve.

With continued effort, critical material requirements for turbine engines may be reduced to the point where they are comparable with those for reciprocating engines now in production.

Summary of Discussion

V. E. Hense, Buick—Is there much of a stress-corrosion problem with Types 403 and 410 stainless steel in compressors?

Thielemann—Types 403 and 410 are used extensively for discs, blades, and vanes in axial-flow compressors. Rusting has occurred, causing deposits of rust and foreign material to build up on blading. Stress-corrosion has not been too prevalent but is becoming more of a problem with these types of steels as parts run at higher stresses to save weight.

R. E. Weymouth, General Electric—The J-47's Type 403 compressor blades have shown some stress-corrosion cracking. General Electric, like Pratt and Whitney Aircraft, is experimenting with coatings.

L. J. Danis, Eaton Mfg.—How about the hardness specification on Type 403 stainless steel compressor parts? Usually it's between Rockwell C30 and C38, which is difficult to achieve on stainless without spoiling the ductility and corrosion resistance.

Thielemann—I agree that it is difficult to achieve a uniform hardness of Rockwell C30 to C38 with Type 403 stainless. From the hardness standpoint it looks to us that perhaps Type 420 is the grade to use. From the stress-corrosion standpoint, however, there appears to be little difference in results whether the hardness is Rockwell C30 or Rockwell C40.

Weymouth—What do you think of titanium?

Thielemann—It looks very promising for compressor parts. There appears to be no stress-corrosion problem. Up to now, we see no other technical reason why it should not be successful for many applications, but, as yet, we have not seen any titanium in aircraft quality, that is, free from inclusions and similar imperfections.

There are problems in connection with the forming and machining of titanium base alloys that have caused some difficulties, but they do not seem insurmountable.

One of the major problems with titanium arises in the forging of rather large pieces having thin sections, such as compressor discs. The trouble is that titanium oxidizes at forging temperatures. The oxide layer is gritty and obstructs the flow of metal in the forging dies. Also, titanium grows large grains if the forging temperature exceeds 1650 F. The large grains decrease the ductility.

E. O. Dixon, Ladish Co.—Titanium saves four to five times its weight in steel for compressor parts. Work-hardenable titanium alloys are hard on tools. Ease of forging titanium depends largely on design.

P. R. Wray, U. S. Steel—I understand that the parts at the hot end of the British Sapphire engine have generally lower alloy content than corresponding parts in U. S. engines. How do you explain that?

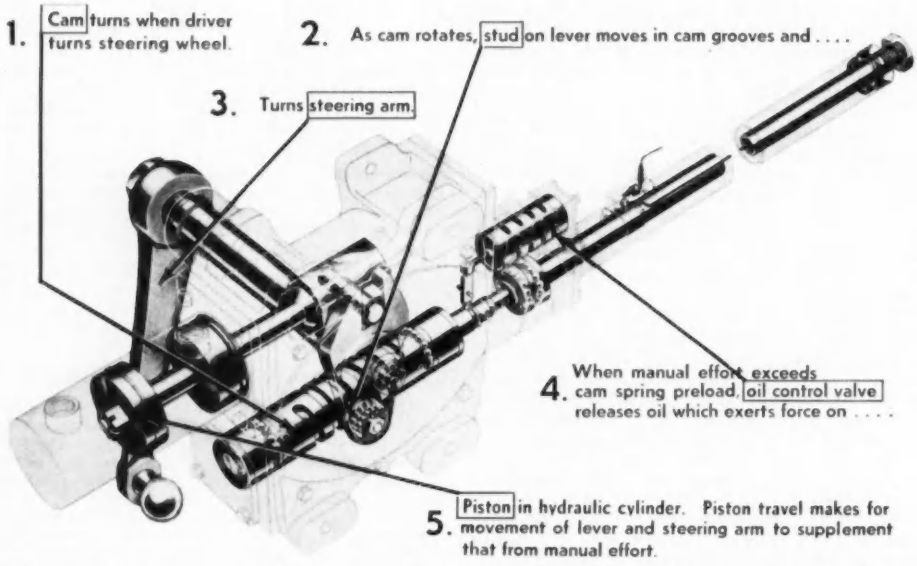
M. H. Young, Wright Aeronautical—That's easy. The Sapphire runs cooler and delivers less thrust per pound of engine weight than the U. S. designs being worked on now.

Car Steering

BASED ON PAPER BY

W. K. Creson, Vice-president of Engineering, Ross Gear and Tool Co.

• Paper "Power Steering in 1952," was presented at SAE Annual Meeting, Detroit, Jan. 15, 1952. (This paper will appear in full in SAE Quarterly Transactions.)


1. Cam turns when driver turns steering wheel.
2. As cam rotates, stud on lever moves in cam grooves and . . . .
3. Turns steering arm.
4. When manual effort exceeds cam spring preload, oil control valve releases oil which exerts force on . . . .
5. Piston in hydraulic cylinder. Piston travel makes for movement of lever and steering arm to supplement that from manual effort.

The Ross Hydrapower steering gear combines mechanical steering and hydraulic boost

How Power

The Ross steering gear (shown above) has a hydraulic power system added to it. The device that transmits hydraulic power to the steering gear consists of a hydraulic pump, a reservoir, a control valve, and a power cylinder. An extension of the lever applies hydraulic power to the cross shaft. This lever extension contacts a sliding member connected to the power cylinder piston. The control valve directs oil flow to the cylinder.

An engine-driven external valve supplies the oil itself.

This particular gear is both manual and hydraulic. When the driver turns the steering wheel either left or right, the cam turns in the same direction. This moves the lever stud through the cam groove, which rotates the lever shaft and imparts angular movement to the steering arm. But whenever the driver turns the steering wheel with an effort greater than the preload of the cam centering springs, the hydraulic system goes to work automatically and relieves the driver of excessive loads.

The valve (shown at right) is the heart of the hydraulic system. The valve housing has several internal oil channels through which the oil flows. A sleeve, with which the housing is fitted, has openings which jibe with the channels in the housing. In the sleeve is a spool with lands that correspond to the sleeve openings. When the valve is centered, each side of each land on the spool is spaced the same distance from a mating edge on the valve sleeve.

The cam centering springs hold the spool in the center position. The cam springs center the cam and in turn the valve spool, unless the steering force is great enough to overcome the spring load. In this case, the cam is dis-

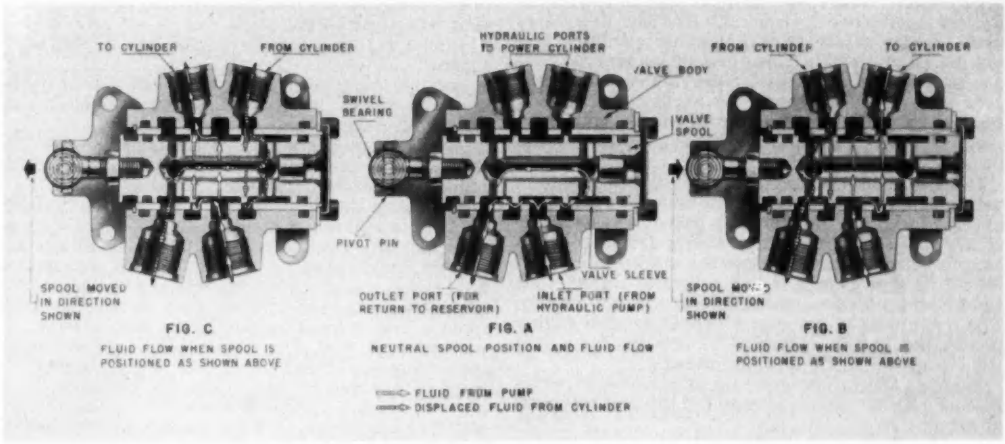
Gets an Assist

TRANSMISSIONS that shift themselves proved to be about the hottest development in passenger cars since the war. Now steering systems that take the muscle out of steering are starting up a little fire of their own in the passenger car field.

From off-the-highway vehicles, to which it had been pretty much restricted, power steering now is reaching out to passenger cars. Although the power steering concept is pretty old, only now is it really beginning to take hold. Its contributions to easier and safer driving have long been recognized. But only after years of testing and development are engineers starting to get the answers to its big technical problems as well as costs.

It looks as if more than 200,000 power steering units will be produced for cars and trucks this year. In 1951 overall production was 40,000 and in 1950, 10,000.

This rapid growth seems bound to continue now that technical obstacles are being hurdled. That's



How the control valve of the Ross hydraulic power system operates

Steering Works

placed in a direction depending on the direction of the applied force.

As the cam moves in either direction, it makes the valve lever move and shift the valve spool. This restricts one of the return passages to the outlet port and causes pressure to increase immediately on one side of the cylinder. At the same time, the opposite return passage has been enlarged; that allows free passage for the fluid from the discharging side of the cylinder to the outlet port.

The increased pressure on the one side of the cylinder exerts a force on the piston and in turn on the inner lever of the gear. Cam travel of only a few thousandths of an inch builds up full pressure. The slightest movement creates a pressure differential.

Releasing driver effort from the steering wheel returns cam and valve spool to the center position.

Suppose the steered wheels are subjected to a shock load. Then the Pitman arm, acting through the inner arm of the gear, shifts the cam and control valve in the appropriate direction to direct the fluid to the proper side of the piston to resist any movement due to shock. This blocking action of the gear prevents kickbacks at the steering wheel.

When the valve is in the center position, the steering action is strictly manual. That permits the driver to get the feeling of "road sense"—that sense of touch to assist the sense of sight. Since the preload of the spring can be varied, the amount of manual effort exerted before the hydraulic boost goes to work also can be varied. This preload is factory set; it cannot be changed in service, except with new units containing more or less springs.

because power steering fills a need. However, like so many comforts of modern living, you don't recognize it as a necessity if you haven't experienced it; but once you've experienced it, you wonder how you've done without it.

We have needed power steering because it easily multiplies our normal capabilities. Parking conditions in modern cities and towns have long called for power steering in cars. The woman—who buys cars, drives them, and has dictated their appearance and many of their features—has given power steering her stamp of approval whenever she's had a chance to sample it. She likes it and now probably will insist on it, now that it can be had for a reasonable price.

At first the man regarded power steering much as he did automatic transmissions when they were introduced: a mere convenience for a woman driver. Now he too has come around to saying that he likes and needs it.

Power steering has more than just extremely easy parking to offer the car driver. Those who have used it on long mileage, in mountain country, and on rough roads report less fatigue and a feeling of greater confidence in control. The car negotiates with greater safety chuckholes, obstructions, and tire blowouts, which cause loss of control without power steering. The quicker steering response that goes with power steering helps avoid collisions and recover from skids. The chassis can be built with greater directional stability, without the traditional penalty of increased steering effort.

If it's so good, why did power steering take so long before it burst into bloom? The concept dates back at least to April 4, 1876, when a patent was issued to G. W. Fitts, on steering of a steam-driven traction engine. That was long before the automobile. Perhaps this slow growth is the nature of things, that fundamental ideas seldom come to fruition quickly. The avalanche is not really caused by the falling pebble, but by the myriad of snowflakes, for a long time dropping softly and unnoticed.

Perhaps the joyous greeting of automatic transmissions by car buyers stimulated interest in power steering.

Transition from Earthmovers to Cars

It's perfectly natural that the limited number of power steering systems made from 1930 to 1950, and particularly from 1940 to 1950, were used on very heavy commercial and military vehicles. Trucks used in strip mining, quarrying, road and damsite construction, grew in size and capacity; the end is not yet in sight.

On some equipment it wasn't mere size and weight that demanded power steering. Performance or earning power was enhanced to the point where power steering equipment paid attractive dividends. On military equipment—such as cargo trucks, personnel carriers, tank retrievers, and combat vehicles—power steering permitted operation at relatively high speeds in rugged off-the-road operations.

Quiet operation of power steering wasn't critical on any of these vehicles. But in applying power to the modern passenger car, noise became a baffling problem that finally was solved.

Another key deterrent to broad use of power steering was cost. Now it seems likely that lower costs are coming. That's because passenger car volume brings with it car production and design techniques that offer many cost-reducing opportunities.

Some of the equipment designed and produced for cars can be used directly on small and medium trucks, and agricultural and industrial equipment. Larger vehicles will continue to need special sizes in smaller volume. But designs will be influenced and costs affected by the design and production pattern set for passenger cars.

Invention and Patents

Just as powering steering has caught the fancy of drivers fortunate enough to have sampled it, so did it fire the inventive talents of engineers and mechanical tinkerers who saw its possibilities since the birth of the automobile. Our patent library has copies of 270 patents relating to power steering. And right now there is lots of activity in the art.

About half the patents pertain to fluid power, with the rest about equally divided between mechanical power take-off and electrical drive. Hydraulic devices also seem to have first call on equipment now available or projected for public use in the near future.

Because many years have passed since the fundamental art was initiated, time has annulled the validity of basic patent claims.

Power steering is a kind of servomechanism. In the fluid power form it might be described in a generic patent as follows:

A steering device comprising means for manual steering, a fluid motor operatively connected thereto to supplement manual effort, a follow-up valve constantly communicating with said motor to control fluid thereto, said valve being exposed to fluid working pressure in such manner that manual steering force is proportional to fluid motor output force.

At present, few if any such generic type claims seem to remain valid as regards patent protection. Most of the recent art relates to various design ways of bringing about the desired result. That's why I think the current art, exemplified by recent patents and development work, can be generally classed as design patents. A fairly large number of variations will result.

The device with the most promising future will have: (1) lowest production costs, (2) fewest service problems, and (3) most ease and flexibility of application.

The devices which are now, or soon will be, in production are mainly for vehicles which were designed for manual steering. Power steering is not always integrated into the design of these vehicles as a whole, but rather adapted to them. As power steering comes into more general use, its physical needs and performance will be considered when new chassis characteristics are first formulated. On vehicles receiving such design treatment, power steering will approach perfection as to performance and freedom from service difficulties, and will be widely used at relatively low cost.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

What Discussers Said about Power Steering

Past, Present, and Future

By Francis W. Davis
Consulting Engineer

THE years of research and development that went into power steering are now bearing fruit. We can only speculate why it's taken all these years to become accepted. But there's no doubt that it will bring easier and safer steering as well as new concepts in steering geometry.

The record shows that power steering isn't new. Here are some of the significant events in its history:

1. In October of 1926 I demonstrated a Pierce-Arrow car fitted with an integral hydraulic power steering gear to three car companies in Detroit. In June, 1928, the same car was shown at the SAE Summer Meeting in Quebec.
2. GMC's Saginaw Steering Gear Division built several experimental booster and integral gears in the late 1920's and early 1930's for both trucks and cars. The Vickers Co. also built some experimental boosters during this period, and in 1931 started commercial production of steering boosters.
3. In 1933 Bendix-Westinghouse started production of the first compressed air steering booster.
4. In the late 1930's Bendix Products Division built a few integral type gears and installed them as pilot models in trucks and buses.
5. In 1939 the Garrison Mfg. Co. sold its first steering boosters on the West Coast.
6. In 1941 Saginaw built several integral type gears for Buick for experimental use in cars. These were used in Chevrolet armored cars during the war.
7. In 1943 Ross Gear and Tool Co. started production of integral type gears.
8. In 1951 Chrysler Corp. announced the first use of power steering in cars. Chrysler's integral type gear was developed in cooperation with the Gemmer Mfg. Co.

The delay in progress with power steering is just what almost every new idea is up against. Between inception and realization of any concept lies a long road full of obstacles.

Twenty years ago General Electric Co. engineers explained the workings of what we now know as electronic controls. In those early days its one and only use was opening doors in the Pennsylvania railroad station in New York. It took 20 years for the basic idea to get adopted commercially to any degree.

Quite a few years ago I argued power steering with the engineer of a truck and bus manufacturer using all the persuasive facts I had. His reply was a disinterested, "And so what?" Today this company is an extensive user of power steering.

Recently I rode in a Mack bus equipped with power steering in New York. I asked the driver how he liked it, and he said: "Too good, too good. It makes it so tough to go back to ordinary steering."

In the future we can look to power steering to inspire broad changes in steering design. By eliminating the effects of softer tires and heavier front ends, it makes possible re-evaluation of all factors involved in front suspension design and steering linkage geometry. So along with steering ease will come improve car stability and cornering characteristics at all driving speeds, under all road surface conditions.

Need Nurtures Invention

By C. W. Lincoln
Saginaw Steering Gear Division, GMC

"WHY has power steering grown so slowly over the years and suddenly burst into bloom?" asks Mr. Creson. It may be that a device enjoys wide acceptance only when a need for it really develops.

That's probably the case with power steering. Certainly the steering gear manufacturers themselves haven't been lax (see Davis Discussion). The need for power steering for heavy vehicles has been a definite one for several years. And heavy power gears have been in production for several years. During that time the need for power steering on passenger cars has been developing. Cars have been growing heavier and tires larger and softer until this need now is a definite one. Result: passenger car gears now are in production.

Of course the uptake of power steering for passenger cars creates a much greater impact on gear manufacture simply because so many more cars than heavy vehicles are produced.

More Work for Fewer Pumps

By E. S. Witchger
Eaton Mfg. Co.

USE of pumps in the passenger car has increased tremendously in just a short time. From one pump per car in 1925 we've gone to seven to nine per car in 1951, plus two to six electric motors to make the driver's chores easier.

But that trend is in for a reversal in the near future. More and more duties will be imposed on fewer hydraulic pumps fitted with flow control and selector valves. Compact and economical engine-driven pump units will speed this trend.

A few years ago most pump manufacturers shuddered when asked to make hydraulic pumps operate at 3000 to 4000 rpm. Today almost all accept 5000 to 6000 rpm, and in some automotive applications pumps are operating up to 10,000 rpm very satisfactorily.

As long as this speed trend contributes to smaller, compact, and less expensive power units, the higher speeds will continue and the difficulties encountered will be overcome as before.

Integral Vs. Booster

By S. I. MacDuff
Bendix Products Division, Bendix Aviation Corp

CRESON raises an interesting point when he compares the future of the power steering booster with that of the integral power steering gear. (With

the booster, the hydraulic system goes to work after manual effort reaches a certain point. In the integral system, both manual effort and hydraulic effort are at work all the time.)

An important advantage of the booster unit, particularly for passenger cars, is its low cost. Whether mass production of integral units can wipe out this cost differential is something I'd like to know.

The integral power steering gear appeals to the chassis designer because it looks like a compact package and is relatively easy to install. But by comparison with manual steering gears, integral units are large and stick out in the wrong places. Not that booster units are always the right size and shape for the space available. But with real effort, you can get pretty clean installations with boosters.

As to steering wheel feel, I believe that booster and integral units can be made almost identical.

Author's Closure to Discussion

IT was a pleasure to have such able help in the discussion of Power Steering in 1952. Davis's chronology is an interesting record for future reference. Power steering from mechanical power take-off was demonstrated in 1927 by C. W. Nierman, as was indicated in the related literature of the paper. In view of the difficulties which confronted and delayed the hydraulic systems now in production, it seems possible that other means of power steering may be susceptible to further development, also.

It has been most interesting to follow the development of power steering, not only from a technical viewpoint, but also from a psychological one. Many automotive engineers have been quite conservative in their estimates of the future of power steering; the more conservative they've been, the more enthusiasm they show, once converted.

Quarterly Transactions Serves Up More Articles

SAE Quarterly Transactions will hit a new high in its April issue both as to number of pages and number of articles. Each issue has been averaging 11 articles and about 150 pages. In April, Quarterly Transactions will grow to 19 articles and 210 pages.

Included in the coming issue are the following articles:

Aircraft

- Low-Temperature Lubrication of Aircraft Engines—by Saul Barron
- Surging in Centrifugal and Axial-Flow Compressors—by R. O. Bullock and H. B. Finger
- Flight Experience with the Vickers Viscount Turbo-Propeller Airliner—by G. R. Edwards
- Characteristics of Propellers for Turboprop Airplanes—by Joseph M. Mergen and Jack H. Kasley
- Trends of Research and Development in the United States Air Force—by Maj.-Gen. Donald L. Putt
- Some Developments for Greater Crash Safety in Aircraft—by Robert J. Schroers

Diesel

- Effectiveness of Amyl Nitrate in a Full-Scale Diesel Engine—by M. J. Anderson and G. C. Wilson

Fuels & Lubricants

- Advantages of Propane as a Transit Vehicle Fuel—by Robert S. Lee
- Economic Relationship of Engine-Fuel Research—by C. L. McCuen

Gear Design

- An Improved Method for Estimating the Fatigue Life of Bevel Gears and Hyphoid Gears—by Wells Coleman
- Beam Strength of Spur Gears—When to Use the Higher or Lower Strength Factor—by R. P. Van Zandt

Materials

- Design and Manufacturing Techniques with Titanium—by O. A. Wheelon

Passenger Cars

- Static Structural Testing of the Automobile Body—by Philip O. Johnson
- Passenger-Car Bodies—Their Design and Development—by A. R. Lindsay
- Humphreys Constant-Compression Engine—by W. H. Paul and I. B. Humphreys

Production

- Increasing Productivity in Production Machining—by Michael Field and Norman Zlatin

Tractors

- Tractor Ride Research—by A. K. Simons

Truck & Bus

- Synchronization of Brakes on Multi-Axle Truck-Trailer Trains—by J. George Oetzel
- Automatic and Hydraulic Transmissions—by O. K. Kelley

Ready to kick-off the discussion on forging are Secretary Thomas Gialdini, Ladish Co.; R. J. Exter, Wyman-Gordon Co.; C. E. Stone, Interstate Drop Forge Co.; Panel Leader J. J. Dierbeck, International Harvester Co.; George Daschke, Packard Motor Car Co.; R. L. Mattson, GMC; and E. O. Dixon, Ladish Co.

Experts Outline

Factors in Forging

REPORTED BY

Thomas Gialdini, Ladish Co.

• Panel discussion on Forging was part of Production Forum held at the SAE National Tractor Meeting, Milwaukee, Sept. 10, 1951, under the auspices of the SAE Production Activity. Panel Leader was J. J. Dierbeck, International Harvester Co.

Question:

What effect does forging temperature have on the machinability of forgings?

Answer:

Some companies feel that forging at lower temperatures increases machinability; others do not. For example, one company which forges crankshafts of AISI C1046 steel at high temperatures experiences no difficulty in machining. It is evident, however, from the fact that some concerns are heat treating before machining that some difficulty with machinability has been encountered.

Question:

What are some of the factors which determine machinability of forgings?

Answer:

The system of quenching is an important factor. Oil quenching suffices for thin sections, but water quenching is necessary for larger sections. Oil quenching may give a non-uniform hardness, which is undesirable. The number of blows made by the hammer does not affect the machinability of forgings.

Question:

To what extent is induction heating being used in the forging industry?

Answer:

Although induction heating is not new to the forging industry, it has gained wide acclaim in recent years. It has been primarily used for heating bar stock.

Question:

What are the relative advantages and disadvantages of the induction furnace?

Answer:

The induction furnace has many advantages; one being a cleaner, less noisy shop. The greatest disadvantage is that a partially formed forging cannot be reheated. The intangible savings are many and can offset the higher energy cost.

Question:

To what minimum can decarbonization be kept?

Answer:

About the best that can be obtained in a stand-

ard type furnace is 0.015–0.020 in. However, in a controlled atmosphere or induction heating furnace, it can be kept to 0.005 in. and less. One way of solving this may be a recarburizing process.

Question:

What frequencies are most generally used for induction heating?

Answer:

Generally speaking, larger bars or billets from 4 in. up are heated on an induction frequency of about 960 cycles, whereas small diameters of 1 in. and over are heated on a frequency of about 3000 cycles. Diameters below 1 in. are heated with 9600 cycle frequency.

Question:

How does the cost of induction heating furnaces compare with fuel-fired furnaces?

Answer:

Prices of induction heating units have increased tremendously, and it is extremely difficult for a company to install induction heating on a competitive basis with the cost of fuel heating equipment.

Question:

What about the cost of maintenance of induction furnace coils?

Answer:

One company found that their cost of maintenance on coils in the beginning was $4 per ton of steel heated, but at present, it is now about $1 per ton. They feel that the price of maintenance should be below 40¢ per ton.

Question:

Is it necessary to specially process a slug before using induction heating on it?

Answer:

Yes, in treating steel some additional processing may be necessary. It is imperative that the slug be sheared with a right angle face and have no ragged edge from the shearing operation if it is to be pushed through a coil in a pusher-type heater.

Question:

What is the best method for shearing high carbon steel?

Answer:

The usual method is heating in a gas furnace, but here heat distribution is not very uniform. The water immersion method is used in many cases to alleviate this situation. One company uses a box-type furnace which encloses the billets and bars.

Question:

What is the feeling regarding hammers versus presses?

Answer:

Both hammers and presses have their relative merits. For example, a very high production of 3280 connecting rods (1¾ lb) per 8 hr was accomplished on a press (2 rods side by side). It would be impossible to maintain this production on a hammer. It is much easier to train a press man than it is a hammer man, because the press dies are engineered to take most of the skill out of forging a piece.

Question:

What advantages does steel shot have for shotpeening as compared to iron shot?

Answer:

The unit cost of steel shot is much higher, but one concern decreased their shotpeening cost approximately 50% by using it. Steel shot has a much longer life than iron shot due to the fact that it does not decrease in size as fast.

Question:

How does shotpeening compare with pickling?

Answer:

Shotpeening not only cleans the surface of a forging but, at the same time, improves surface hardness. One company decreased their cleaning costs from $1.89 per ton using the pickling method to 80¢ per ton using cut wire shot and shotpeening the small forgings.

Question:

Is there any difference on the forging itself due to using steel shot or iron shot?

Answer:

No appreciable difference has been found.

Question:

Is steel shot and steel cut wire shot readily available at this time?

Answer:

Yes.

Question:

Approximately what surface depth of hardness is obtained by using shotpeening?

Answer:

Surface hardness usually penetrates to a depth of 0.003 to 0.005 in. when shotpeening is used. If a greater depth of penetration of surface hardness is desired, cold rolling may be used to advantage.

Engineers Alerted...

- To New Approach to Engine Design
- To Radiator Materials Substitutions
- To Ways of Stopping Spark-Plug Fouling

MORE than ever before the automotive engineer has to keep as fast-stepping as an adagio dancer in shaping his job to conditions dictated by national defense needs. This one fact stood out to more than 1000 members and guests at technical sessions and dinner talks at the sixth SAE National Passenger Car, Body, and Materials Meeting in Detroit, March 4-6.

Engineers crammed session halls to hear how radiators can be made in the face of a squeeze on copper forced by defense needs. They learned there's still a long row to hoe before this challenge can be met. Engine designers were told to veer away from the higher compression ratio route because national defense restricts fuel quality improvements. Transmission men heard what the military want of them in the way of better torque converters.

These overtones of austerity and ingenuity forced on automotive designers pervaded even those sessions devoted to purely technical problems imposed by commercial vehicles.

Defense Drains Engineers

SAE President D. P. Barnard told those at the dinner that military production compels automotive men to double in brass. From cars, trucks, and buses they have to turn to planes, tanks, and guns. What makes the job particularly tough is that there aren't enough engineers to go around.

The only course open, said Barnard, is to make better use of engineers right now and to stimulate student engineers and bright youngsters to make automotive engineering their career. Use engineers to their fullest technical capacities and relegate routine jobs to aides, he urged. That'll increase the engineer's efficiency, bring him greater compensa-

They Broadcasted about Meeting . . . . . and They Wrote about It

Newspapers, trade magazines, and radio stations gave the meeting both local and national coverage. In the picture at left, General Meetings Chairman Robert Insley (center) is giving Detroit radio listeners a capsule review of meeting highlights. George Gaudaen, Automobile Manufacturers Association (right) handled public relations for SAE at this meeting. In the picture at right are some of the 22 newspaper and magazine reporters who wrote stories about the meeting

tion, and attract more capable youngsters to the profession.

The implicit role of engineers in keeping the free world that way carried over in an address by Gen. George C. Kenny, USAF (Ret.) "You can't win a war without air control, and you won't lose it if you rule the skies," said General Kenny. Right now the Russians are rolling out planes, A-bombs, and other armaments at a menacing rate.

Only three alternatives remain in the struggle between ideologies of East and West.

1. Economic catastrophe in this country, which the Russians have come to believe won't happen here.

2. Political crack-up here or in Russia. But it's not probable in the USSR since history shows the Eurasian is apathetic, accustomed to despotism.

3. The final answer is in military strength. If we have the bigger stick, we can force the Russians to quench the bonfires of upheaval they're fueling throughout the world. Otherwise, when Stalin feels he has enough military superiority, he'll strike a knockout blow at this country.

In the military struggle, we don't stand a ghost of a chance in ground bayonet warfare. We're pitifully outnumbered by the Red hordes. Our Navy stands ready and able to do a job. But Russia has the biggest submarine fleet in the world and would wreak havoc with over-water transport of men and supplies. And the Eurasian land mass is too huge to fence in with warships.

Only the air remains as a means of salvation.

Don't sell Russia short as a backward oxcart nation, warned Kenny. She has more steel and oil now than Germany did when she set out to conquer the world. And the tanks, planes, artillery, and electronic equipment our potential enemy is making can match anything else in the world today.

Russia will strike when she feels sufficiently stronger than us, and then there'll be no stopping her. Even with a complete intercepter network—fighter planes and radar—we could hope to stop only 25% of the Reds' A-bomb packing bombers. And we're far from having completed our defenses.

Kenny feels we'll be forced to throw in the towel once the Russians have laid low 10 to 15 of our key cities. And they're probably close to having all the A-bombs they need to do such a job.

So its better to shell out now for weapons to keep from being over-run by the Reds, than to skimp on military expenditures and face enslavement, opined Kenny.

Steel and Aluminum

Fall Short of Replacing

Copper in Radiators,

Report Engineers at . . .

Sessions on Materials for Cars

FOR the time being the heat seems to be off the automotive industry on replacing copper in radiators. That's due to a recent allocation of more copper to the industry by the National Production Authority. And it's a good thing, agreed engineers at the meeting. Right now there just isn't anything good enough to fill the shoes of copper and brass, even though development is still going on in case a real pinch comes and forces substitutions.

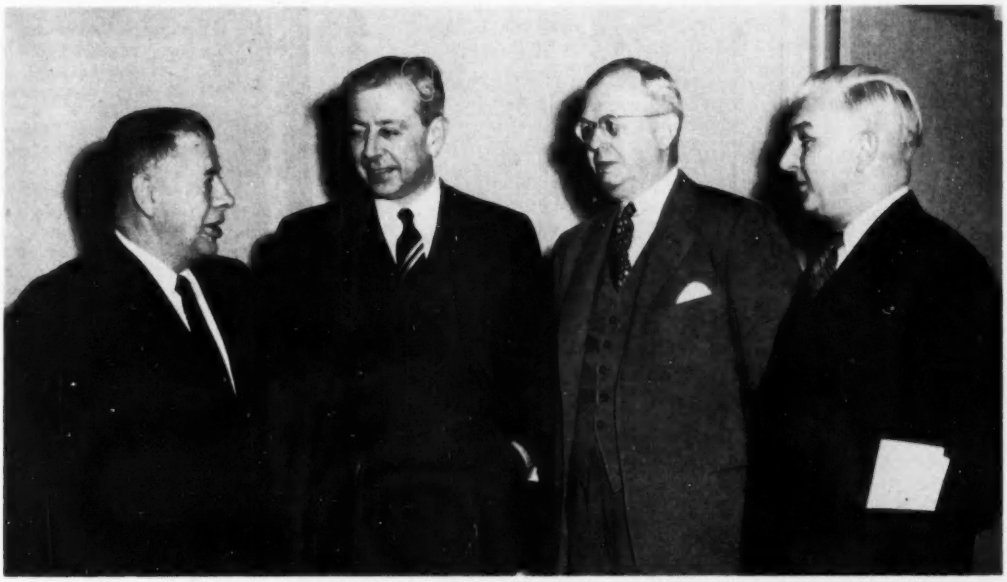
Joseph Gurski, Ford Motor Co., summed it up pretty well when he said there just aren't commercially available substitutes that will come near copper and brass. Sure, you'll save 25 to 35% copper with clad materials, but you've got to accept shorter radiator life as a consequence. And materials and fabricating costs will run 15 to 35% higher with any substitute. That doesn't even include additional tooling costs which substitutes will bring on.

"How can you plan for substitutes when you don't know what'll happen 30 days from now?" asked Gurski. A plant can't switch overnight from copper to substitute material radiators. Tooling has to be planned, and there's at least a three to four month lead time on materials alone. No one wants to go to inferior radiators—that will cost more to make—when perhaps conventional materials will be available after all.

Cooper on Copper Economies

A better bet than substitutes is to continue with copper but to stretch it over more units. By smart design it's possible to pull copper and brass out of radiators and ease shortages, argued James H. Cooper, of the McCord Corp. Redesign of not only

They Spoke at the Dinner



Left to right: Gen. George C. Kenny, USAF (Ret.); SAE President D. P. Barnard; Robert Insley, toastmaster and chairman of General Committee; and W. H. Graves, chairman, Detroit Section

the radiator, but other parts of the car as well can squeeze pounds of critical materials out of each vehicle, he argued.

Change the cooling system or conditions affecting it to improve air-to-boil temperatures just 4 F and here's the prize in store: You can cut the number of fins per radiator and save about 1 lb. of copper per unit. Not only will that net 800,000 lb of copper for the industry on that many cars, but the individual car maker can save himself about 44¢ per unit.

Bumper forms and locations can put a crimp in cooling efficiency that costs in copper, said Cooper. On one new car pilot model the lower two-thirds of the bumper face was convex, the upper third concave. It acted as a deflector and forced air away from the grille so as to cause a 3% cooling loss at 60 mph. Correcting this could mean a saving of perhaps 2 lb in copper per radiator. In another case, relocating horns from the front of the radiator to the side improved cooling 4%.

One car manufacturer did some of these things and cut the weight of critical metals to only 51% of that used in his 1951 model. He redesigned his engine to lower heat rejection and also went to rounded radiator tanks and headsheets instead of rectangular shapes. The latter changes permitted higher pressures and much thinner cores.

Even after engineers exhaust their design ingenuity and there still isn't enough copper to go around, then what? Aluminum may be one of the answers. It's got a lot of virtues, but also some real drawbacks at this stage of the game in its development for radiators, men at the meeting advised.

The switch from copper to aluminum could save the industry 50,000 to 62,000 tons of the red metal annually, noted J. H. Dunn and E. P. White of the Aluminum Co. of America. Two things have stymied the changeover: (1) a way of fabricating aluminum radiators, and (2) corrosion once they get into service.

The Alcoa men felt dip brazing is the best way of building an aluminum core. Several experimental units built this way, they said, show the brazing material is integral with the sheet, good fillets and joints are formed under proper brazing temperatures.

What's been bothering the car makers on the service side is the corrosive action of waters in various parts of the country. It's about the same thing that happened to aluminum tea kettles years ago. They failed from a pitting kind of attack. The tea kettle trouble brewed itself out when an aluminum-zinc alloy cladding was applied to the aluminum sheet.

The same thing might work for aluminum radiators. Alcoa now has a sheet consisting of a 3S core, with a brazing alloy on one side and an electrolytically protective alclad coating on the other. Radiators of this material work pretty well with various type waters and antifreeze solutions, tests showed. But some waters may need an inhibitor or an exterior paint coating for the radiator.

The problem isn't quite that simple, observed J.

They Head Activities of Meeting

Left to right: V. M. Exner, vice-president for Body Activity; H. E. Churchill, vice-president for Passenger Car Activity; and V. A. Crosby, vice-president for Engineering Materials Activity

R. Holmes, chief engineer of GMC's Harrison Radiator Division. He admitted that aluminum has some pretty attractive features—such as lighter assembly weight, pretty good heat transfer characteristics, good availability, and ability to take cooling system pressures. But they don't look so important when stacked up against the headaches.

Here are a few troubles Harrison Radiator ran into with aluminum:

1. Aluminum radiators cost lots more than copper because the salt bath is expensive. Each radiator dipped into the salt bath drags out about $2.00 worth of the stuff.
2. It takes more operations to make the core and even calls for some hand welding.
3. Closing voids or leaks is one problem that hasn't been solved. Plastic materials have been tried, but no one knows how well they'll really hold up.
4. With currently available aluminum brazing sheet, it's practically impossible to make the cellular type core.
5. Right now there's only one source of salt for dipping. What's available won't even fill needs of Harrison's production, let alone supply other radiator manufacturers.
6. Fixtures for holding parts in the salt immersion are elaborate, cost a lot, and last for only about 100 immersions.
7. Since brazing takes about 10 times the weight of salt to that of product, plus fixtures, a manufacturer would need a terrific amount of floor space and capital investment for high production of this type unit.

Other substitute materials aren't lacking in woes either. Gurski sized up other substitution possibilities one-by-one and it boiled down to this:

- Steel or even painted steel primary parts (tanks, headers, and tubes) won't do. Preliminary coating on steel won't hold up because of heat of soldering. It's impractical to coat steel after soldering because the surfaces are oxidized.

- Copper-clad steel is only as good as the coating. It's never 100% continuous and is bound to have inclusions. Localized corrosion starts at these defects.

- Brass-clad steel may be slightly better because it doesn't score forming dies as badly, but the coating defects are still there.

- Lead-coated steel for tanks and headers is bound to be porous. There's no production inspection method that'll catch all the porous stuff and some is bound to sneak through.

- Copper-plated steel is impractical for tanks because of intricate shapes. There is no production plating process that'll do a fast and uniform job. Also plating is inherently porous.

For radiator parts like fins you run into this kind of stumbling block, said Gurski. Since you need good thermal conductivity and the replacement materials don't measure up to copper in this respect, units are bound to get bigger and heavier and take lots of expensive engineering to design them. Steel

won't do for fins; it adds too much weight and rusts too easily. Copper-clad steel will call for protection of the cut edges and a better paint job. There's really little service life data on this material.

If substitute materials start going into radiators in sizable quantities, inhibitors for coolants will take on added importance. R. W. Scoville, of Chrysler Corp., said that up to now inhibitors have been added to prevent corrosion of other parts of the cooling system. Now they'll have to do a job on radiators as well. In the summer particularly motorists will have to add inhibitors, since most antifreeze has inhibitor in it.

Everytime you think you know all the junk a motorist can throw in a cooling system, someone comes up with a new one, said R. J. Birkholz, International Harvester Co. He told of a user of his company's equipment, a $20,000 unit at that, who insisted on using diesel fuel oil as antifreeze because glycol and alcohol blends cost too much. Why not get around this whole corrosion situation by going to a sealed system with which the motorist can't tamper, asked A. B. Arnold, of Modine Mfg. Co.

Holmes said the hickey here is that the engine builder would have to redesign his powerplant completely. The coolant would have to stay in the system not only all year 'round, but years around. Any known inhibitor will break down sooner or later. Pumps that don't leak have yet to be built. And then, too, gaskets often let combustion products leak over to the coolant passages, sometimes because of head warpage.

Harry Knowlton of International Harvester got an "aye" from all at the meeting when he said testing new materials until you're sure what they can do is what's holding up progress on substitutions. Continued Knowlton, "Only after you've built and put into service several million radiators over six or seven years do you have any reliable data. And then what you've found out is everything about the best materials of six or seven years ago."

Other Roles for Aluminum

The sledding may still be rough for aluminum in replacing copper in radiators, but this light metal is finding the going easier in other places. Wiring is one of them.

Aluminum conductors in electrical power transmission isn't new. But since 1946 Alcoa has been developing the stuff for automotive wiring such as battery cables and ignition harnesses. What held up its entry in these uses is the hardness and stiffness of aluminum drawn wire. Now there is a type that's flexible, has good strength, and fatigue resistance.

Aluminum also will give copper a run for its money in coiled tubing, the Alcoa engineers implied. The company recently came up with an aluminum coiled tube that costs much less, bends more easily, and work hardens less than copper. Known as

They Saw What They Heard About

Engineers take a close look at aluminum and magnesium parts, made of new alloys and by recent fabricating methods, after speakers talked about these light metals

Alcoa Utilitube, the tubing looks pretty good for automotive brake, fuel, and oil lines.

Aluminum was said to promise some dollar savings in castings too. Now that aluminum brazing techniques have been perfected, aluminum castings may show a big gain over cast iron. Instead of making iron castings with intricate coring which shifts or breaks, simple aluminum sections could be cast and then joined by brazing. It's been tried for engine cylinder heads and even blocks on an experimental basis.

Magnesium's Future Bright

Just as aluminum is moving in on copper, so magnesium is competing with conventional metals for vehicle use. New alloys and improved fabricating techniques are helping ease this light metal into the automotive field. The incentive: cost and weight savings.

Die casting is a case in point, said Dr. J. D. Hanawalt, of Dow Chemical Co. You need four times as much metal by weight for a zinc casting as against the same part in magnesium. Even though zinc may cost about 15¢ per lb as compared with 30¢ for magnesium, you still halve your materials costs by switching to magnesium.

Dow engineers Hanawalt and Glaza said magnesium is a cinch to machine. It can be cut at higher speeds and feeds than any other metal, and power consumed in machining is two-thirds that for brass and aluminum, one-third that for cast iron, and one-sixth that for steel.

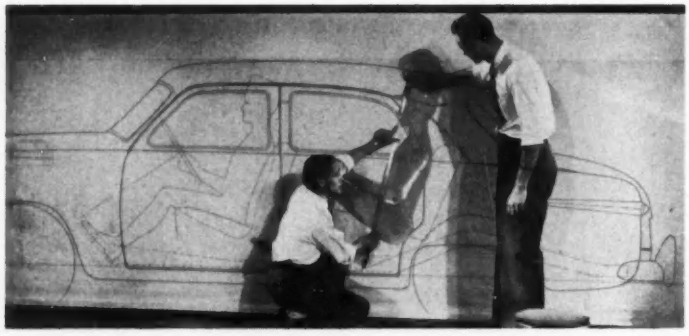
A Michigan manufacturer recently went to magnesium permanent-mold castings for a convertible top-folding mechanism, and saved 35% in machining costs. An auto maker said his cutting tools last three to 10 times longer when machining magnesium as against aluminum. Tap life increased 10 to 15 times. Thompson Products had to resharpen its carbide cutting tools every three or four days in cutting aluminum, only every three or four months with magnesium.

Another new technique, impact extrusion, promises to pay off in a big way. In this process, a hot lubricated slug of magnesium is placed in a heated die and hit with a pressure of 40 tons per square inch. All kinds of shapes—round, square, and even parts with ribs, flanges and bosses—can be made this way. They have been used for knobs, shields, housings, and structural clips.

Weight saving may be on a par with cost economies of magnesium. Airplanes are fitted almost exclusively with magnesium landing wheels and now it looks as if ground vehicle makers may take a cue from plane engineers.

A 9-lb magnesium wheel for passenger cars replaced a 20-lb steel wheel and showed good service in tests. On a tandem-axle, dual-wheel commercial vehicle the wheel assembly weighed 1088 lb in steel, only 488 lb in magnesium—a saving of 600 lb.

Engineers Differ over Ways to Remove Bugs And Lengthen the Life Of Components in . . .



Passenger Car and Body Design

A "nothing-is-so-well-designed-that-it-can't-stand-improvement" attitude prevailed at Passenger Car and Body sessions. At one session after another, experts pointed out the need for improving the design and operation of passenger-car bodies, engines, and component parts . . . and, in many cases, told how to do it.

Meeting audiences learned that volumetric efficiency, not compression ratio, will be the criterion for design of some future engines; that combustion chambers should be designed for smooth flow; that hot plugs and the additive, tricresyl phosphate, deter lead fouling of spark plugs . . . and that complex structures can best be portrayed by pictorial drawings.

Breathing Versus Compression Ratio

Certainly passenger-car engines will always be a fertile field for design improvements noted Chrysler's J. C. Zeder, who opened up a second avenue in the car engine power race. He called for a pause in the ascent of compression ratio and argued for improved volumetric efficiency as a design road rife with opportunity.

Zeder labelled compression ratio as a path "too slippery for use in the immediate future." Boosting compression ratio puts the squeeze on oil refiners to come up with higher octane fuels . . . and every boost in octane number burns up millions of dollars in investment for refining equipment. What's more, he added, demands of military preparedness don't augur much of a rise in fuel quality, at least for the immediate future.

It's a lot sounder to get greater output by improving volumetric efficiency—enhancing the engine's ability to breathe the air-fuel mixture. Then the engine designer doesn't have to confine himself to fuel technology improvements to raise engine power, reasoned Chrysler's top engineering executive.

And proof of the pudding, Zeder went on to say, are Chrysler's two spherical combustion chamber engines—the FirePower and the FireDome eights. Both are hefty power producers (180 hp and 160 hp, respectively), and yet they run on regular grade gasoline.

The basic spherical chamber design, used in both these engines, is loaded with opportunity for increasing engine output and efficiency, Chrysler tests show. It's just a matter of providing better engine breathing components. In fact, torque was upped 60 lb-ft and power output 95 hp by making these few experimental changes: enlarging the intake valve $\frac{1}{8}$ in. and the exhaust valve $\frac{1}{4}$ in.; changing intake manifold design and using four single carburetors; camshaft redesign to increase time of valve opening; and streamlining the exhaust manifold.

Carbon Like Snowflakes

Once power is built into an engine, though, it's important that it be there to use. And if power losses due to combustion chamber deposits are to be kept to a minimum, A. E. Cleveland and E. Enoch, of Ford, advised, then combustion chambers must be designed so that they have smooth flow patterns.

Areas of combustion chambers where changes in air velocity are greatest (quench areas) show higher concentrations of deposits than areas of little or no change in velocity. Thus, it was theorized, as a snow fence precipitates a snowdrift by upsetting the air currents at that point, so a quench area may precipitate lead salts from the air stream.

To Cleveland-Enoch, this explains why overhead valve engines—with fewer snow fences intrinsic in their design—are less susceptible to deposit power loss than L-head engines. And the overhead valve engine which showed practically no deposit power loss had direct flow of gases through the combustion chamber. It didn't even have the conventional quench area . . . further support for reconsidering combustion chamber design.

Deposits not only emphasize deficiencies in combustion chamber design, but also point up the need for improving spark-plug performance—especially against lead fouling. Plug fouling is not a new problem, but it's certainly growing more serious. That's due to recent trends toward more powerful engines (resulting in more part-load operation) and greater traffic congestion.

But the solution to this problem may not be too far around the corner . . . if any or all of the "possible" remedies suggested by researchers at one ses-

Rib Ticklers from the Meeting . . .

Engineering concepts, empirical values, and physical phenomena got their fair share of attention at the meeting. But in and between technical sessions automotive engineers managed to demonstrate the value of the "guffaw factor." Stories and puns ran the gamut of audience reactions—from titters to belly laughs. Here are a few that made the rounds:

M. F. Garwood, of Chrysler, said he knows why the Russians knocked the stuffings out of the German army on the Eastern front in the last war. They had an Irish general—Tim O'Shenko.

* * * *

An engineering executive complained to his physician of insomnia, so the doctor gave him some pills. Several days later, continued SAE Past-President A. T. Colwell, of Thompson Products, Inc., the executive came back to the doctor and said: "Doc, that stuff didn't work. Can't you give me something like twilight sleep that'll stop these sleepness nights?"

"We can't give you that," said the doctor. "Twilight sleep is for labor."

Replied the executive, "Then don't you have anything for management?"

* * * *

While standing on the corner one day, W. K. Norwick, Fisher Body Division of GMC, was approached by a panhandler who asked him for $1. "Why ask for a dollar? Times aren't that bad," said Norwick. "You'd do better asking for a dime or a quarter."

"Listen, mister," retorted the bum, "I don't care how much you give me. But don't tell me how to run my business!"

* * * *

C. F. Kettering once left this parting remark with one of his classes about to graduate, recalls D. F. Caris, GMC: "Well, fellas, I've worked with you for several years and told you everything I know. But I have one confession to make—50% of what I've told you is wrong . . . trouble is that I don't know which 50%."

sion pan out. We've found a number of ways to combat this evil, these experts reported, but there still are "ifs" attached to some of them.

For example, H. N. Metzel, of GM's Oldsmobile Division, noted that extensive, but incomplete, field tests indicate that hot plugs do not foul as soon as cold ones in city-traffic service . . . and special high electrical-thermal conductivity electrodes in either type plug produce measurable improvement, especially in the case of the hotter plugs. There still remains the question of whether a plug that offers improvement in this respect will do for all around use. It'll take many more thousands of miles of test work to get the answer.

The mere fact that there is an optimum spark plug for each type of driving points to a possible solution, added M. M. Roensch, R. C. Beaubier, and H. J. Chalk of Ethyl. If car manufacturers would base plug selection more on service in light-load operation and, at the same time, train service departments to correct for unusual operating conditions, much could be done to minimize lead fouling.

Chemical Fouls Fouling

Another possible approach, Metzel went on to say, would be a fuel additive that retards lead fouling. And tricresyl phosphate may well prove to be this additive, reported R. J. Greenshields of Shell. Field tests to date indicate that spark plugs operate twice as long before fouling when small quantities of this supplementary scavenging agent are added to the fuel.

But there may be some drawbacks to using tricresyl phosphate, Greenshields freely admitted. So far it is not known what effect it may have on other engine components. Studies to determine this will be made. D. F. Caris, of General Motors, agreed that this must be done, for additives of this type have been known to reduce valve life.

Any of these approaches may well lead to improved spark-plug performance, another speaker concurred; but proper installation of spark plugs will still be all important. Said H. H. Vogel of Champion Spark Plug, many times spark plugs are installed properly at the factory, then not properly reinstalled by dealer mechanics who remove the plugs to check them. This leads to plug overheating . . . more deposits . . . and more lead fouling.

"Nothing is so well designed that it can't stand improvement" applies not only to the powerplant, but also to components which contribute to safer, smoother, and more comfortable rides. Body, chassis, and suspension engineers pointed out that improvements can be made in body strength and rigidity, suspensions, tires, and noise level.

Stiffening Convertible Bodies

A great deal can be, and is being, done to improve the rigidity of convertible bodies, indicated E. L. Allen, of Schonitzer Engineering Co.

Use of doors as structural members, heavier gage sill members, and specially anchored and braced body pillars all help to reduce objectionable movement caused by lack of structural members over the top of convertibles. Even much more rigidity could be gained by using permanent roof side rails, emphasized Allen, if customers would accept this design. Ounces of weight in bracing across the top of the body structure will do more good than pounds added to the underbody or chassis frame.

Furthermore, much can be done to reduce objectionable movement by studying and experimenting with the location of body hold-down bolts. Addition or elimination of a bolt may dampen out a movement at its source, or prevent it from being transmitted from the frame to the body.

Still another way to increase the strength and rigidity of passenger-car bodies is to use extended front-fender splashers, Packard's L. H. Frailing pointed out. This simple expedient—which permits the front-end sheet metal assembly to be more rigidily attached to the frame—can increase torsional rigidity at the front axles by 20%.

Passenger safety aspects were reaffirmed by tire engineer E. A. Roberts, of Armstrong Rubber, who pled for better tire traction.

Present-day trends toward shifting more weight to the front end and use of more powerful engines add up to less tractive ability . . . and must be given more attention by car and tire engineers.

Roberts reported that one way to improve traction is to design tread elements that act as ribs when freewheeling down a highway, but which break up into separate, interlocking elements when needed for traction.

Electronics Bests Slip-Stick

And—while it is most important to package the passenger safely—increased emphasis on comfort and general ride performance calls for improved suspension systems. Electronic "simulators" are going to be extremely valuable tools in developing these new and better systems, according to A. Lange, Lear, Inc., and J. Dute, of the University of Michigan's Engineering Research Institute.

It has long been possible to analyze suspension systems mathematically, Lange-Dute noted, but solutions obtained in this manner may be costly and impractical. However, by using an electronic simulator, quantitative, as well as qualitative, information concerning the various modes of motion can be obtained quickly and easily.

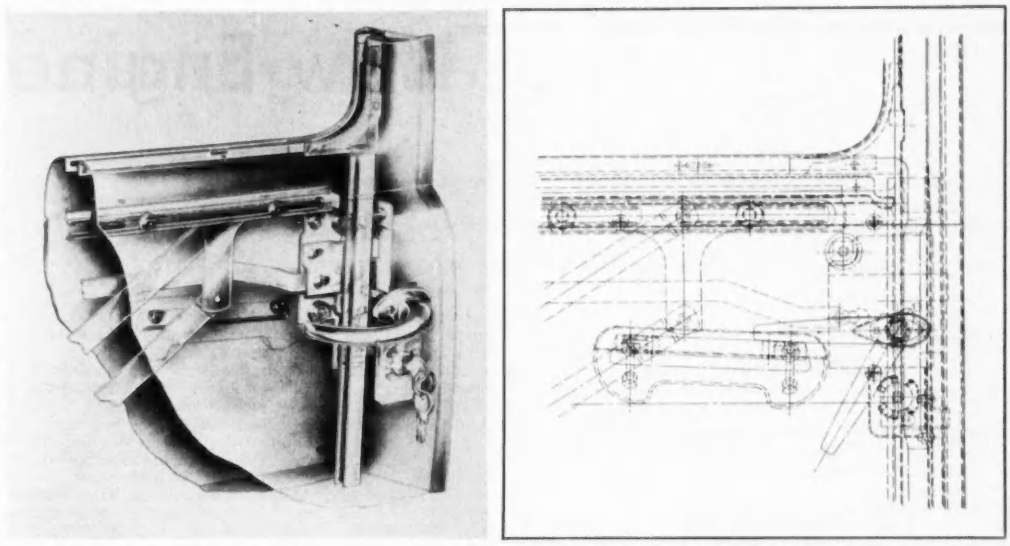
Called a simulator because its component parts are arranged to represent the action and motion of the various suspension elements, the computer is an actual model of the vehicle and its behavior. Consequently, it can be used both to analyze the motions of vehicles already built and to synthesize the motions of vehicles before they are built.

Discusser P. H. Pretz, of Ford, felt that the simulator might find wider usage in such applications as engine vibration studies—where the desired result is more evident, and the initiating disturbances more precisely defined.

Chrysler's L. M. Ball sailed into the question of passenger-car comfort from the standpoint of car noise and told how it, too, can be improved. The unpleasant, mechanical noise caused by crankshaft vibration — so often heard in torque-converter-equipped cars — can be substantially reduced, this engineer asserted. Only design change necessary is to use a thick, stiff drive plate between the torque converter and crankshaft, instead of the customary thin, flexible one.

T. C. Gleason, of Chrysler, chimed in with the thought that today's passenger-car heating, venti-

This . . . . . Is Better Than . . . . . This



Pictorial drawings (left) are far better than orthographic drawings (right) in showing complex structures, engineers were told at one session. Not only do these graphic illustrations bring out design details obscure in orthographic drawings, but they're smaller—and save money, too

lating, and air conditioning systems can stand improvement.

Warm-up time of heating systems is too long, he noted. And, under heavy traffic or parking conditions, "fresh air" taken into heating and ventilating systems is not always fresh . . . since the air intake is often located at the front, where exhaust from other cars is directed into it.

Furthermore, while mechanical refrigeration does offer advantages, a suitable place for storing the condenser has not yet been found. Its size and weight, together with that of the compressor, will also have to be reduced, Gleason felt.

Self-Shifting for the Military

However, while automotive engineers are continuing to devote energy toward improving pleasure cars, one of their immediate concerns is to improve military vehicles. An important step in this direction, reported J. E. Storer, of GM's Allison Division, is the recent development of a "crossdrive" transmission for tanks.

So named because the principal axes of its most important elements are arranged transverse to the vehicle, this torque converter unit—with its combined functions of steering and braking—is 27 in. shorter and approximately 50% lighter than its predecessor.

Other outstanding features of this new production package, Storer pointed out, include: (1) high power availability over a wide operating range, (2) high vehicle maneuverability with ease of operation, (3) simplified controls, and (4) construction which permits quick diagnosing of trouble and speedy teardown for replacement of worn parts.

Blueprints Go Arty

Once the product has been designed, it's got to be easy to manufacture—with no chance for mistakes by the shop. And orthographic drawings don't fill this bill, asserted A. L. Bradley, of Creative Industries of Detroit.

Pictorial or perspective drawings, however, bring out details that are obscure in orthographic drawings . . . and they're far easier to interpret. Man-hours can be saved all the way down the line—from the executive who has no time to spend poring over layouts before making a decision . . . to the production worker who can do a much better job when furnished with prints he can understand. What's more, Bradley added, perspective drawings are smaller and generally lower in cost.

Further support for use of perspective drawings came from two engineers responsible for preparation and release of engineering information to production—H. S. Kaiser of Pontiac, GMC, and E. R. Ford, Ford Motor Co.

Kaiser reported that he has yet to find any serious criticism or deficiency with this type of drawing. On the contrary, tool processing time and manpower often can be reduced by more than 50%. Other benefits to be gained, Ford added, are time saved in getting into production, improved inspection procedures, reduced travel and phone costs, prevention of errors, and shorter training time of production personnel.

New Engine

EXCERPTS FROM PAPER BY

Albert Willi, Jr.

Federal-Mogul Corp.

FORTY per cent lead copper-lead bearings have definite advantages for use with slow speed diesel or gas engines.

Data on seven different engines (one 2-cycle and five 4-cycle diesels, and one 4-cycle gas engine), ranging in bore from 8 to 16 in., show that the most striking improvement of this material over babbitt is its increased load capacity and fatigue resistance. To obtain these advantages, conformability, embedability, and wear rate suffer somewhat. However, this sacrifice has not proved detrimental.

Fatigue resistance is far superior to that of babbitt. No bearing metal breakdown or cracking due to fatigue has been reported in 13,000 to 17,000 hr, whereas babbitt bearings in these same engines began cracking in 5000 to 8000 hr.

Conformability, enhanced by the application of lead-tin overplate 0.001–0.002 in. thick, appears to be adequate to conform to the usual irregularities and deflections of the slow speed engine.

Embedability is also judged to be entirely adequate. Foreign particles in the lubricating oil have not been particularly troublesome—no doubt due to the excellent filtration systems used in engines of this type.

Copper-lead is, of course, subject to corrosion by certain acids formed in the lubricating oil. However, corrosion presents no problem if the oil type and change period recommendations of a reputable oil manufacturer are followed.

Shaft wear with this overplated bearing has been no greater than obtained with the babbitt type. Furthermore, the non-seizure characteristic of this copper-lead has been adequately demonstrated in laboratory and engine tests by running such bearings without the overplating.

(Paper, "High Lead Copper-Lead Bearings for Slow Speed Diesel Engines," was presented at SAE Annual Meeting, Detroit, Jan. 16, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

EXCERPTS FROM PAPER BY

A. R. Shaw

Moraine Products Division, GMC

MORAINE-400 has evolved as a bearing with very promising potentialities. The result of eight years of development and dynamometer testing, and three years of field testing, this steel-backed aluminum alloy bearing offers six to ten times the bearing life of conventional babbitt bearings.

Tests showed that where babbitt bearings in a GM medium-duty truck engine run about 100 hr of endurance testing, Moraine-400 bearings will run 750 hr with ease.

Durability and long life of this material result from a combination of individual properties, such as antiscoring, fatigue resistance bond, embedability, conformability, corrosion resistance, and load-carrying ability.

To date there have been no failures in engines attributable to fatiguing or bond failure—nor failures from scoring where the bearings have been properly designed and installed. Embedability is, in our opinion, phenomenal, conformability excellent, and corrosion is not a problem. Load-carrying ability is from four to six times greater than that of the types of babbitt bearings currently used.

Laboratory tests conducted on an Olds V-8 engine indicate that, with Moraine-400, bearings are no longer a limiting factor in engine design. As long as the shaft is of sufficient diameter to handle the torque which is taken from it, and the journals long enough to allow for a practical oil hole design, there is sufficient area for adequate bearing life.

From the test work conducted, it has been found that Moraine-400 is completely interchangeable with either bimetal or Durex-100 bearings, and not only will it run on an oil hardened shaft, but tests indicate that an oil hardened shaft is preferable.

(Paper, "Moraine-400 Engine Bearings," was presented at SAE Annual Meeting, Detroit, Jan. 16, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

BASED ON PAPER BY

A. E. Roach

A. F. Underwood

Research Laboratories Division, GMC

SLIPPER-type gridded silver bearings proved the answer to a key design problem raised by the 1200 hp diesel "Pancake" submarine chaser engine. Use of this type of bearing on the connecting rods provided one more way to keep engine weight down—a basic requirement in this 16-cyl, vertical-crankshaft radial engine.

In keeping with the basic requirement of lightness, each of these bearings encompasses only 66 deg of the crank-pin, which permits the four rods in each radial bank to be connected to the same crankpin. (See Fig. 1.)

Very high bearing loads required the use of a bearing material possessing extremely high fatigue strength, good score resistance, and good embedability—a combination of properties not generally compatible. In addition, the bearing material had to lend itself to attachment to the slipper end of the connecting rod.

A grid-type bearing appeared to offer a solution since a bearing of this construction would satisfy fatigue

Bearing Designs

. . . carry heavier loads, last six times longer, and save engine weight. But installation and maintenance still key to long life and satisfactory service.

strength, score resistance, and embedability requirements. But a means had to be found to attach it to the slipper end of the rod.

A highly efficient process for bonding a silver pad to the rod was developed. This pad was then knurled, and the indentations filled with a lead-tin alloy. Diamond boring produced a smooth surface containing a multiplicity of diamond-shaped areas of lead-tin, possessing good embedability and frictional properties—surrounded by an interconnected grid or network of silver, possessing good fatigue strength and load-carrying ability.

The service record of the slipper-type connecting rod with gridded silver bearings has been exceptionally good. Nearly 500 "Pancake" engines, using these connecting rods, saw service in submarine chasers during World War II, and no complaint was ever received about the performance of the bearings.

(Paper, "Slipper-Type Bearings for Two-Cycle Diesel Connecting Rods," was presented at SAE Annual Meeting, Detroit, Jan. 16, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

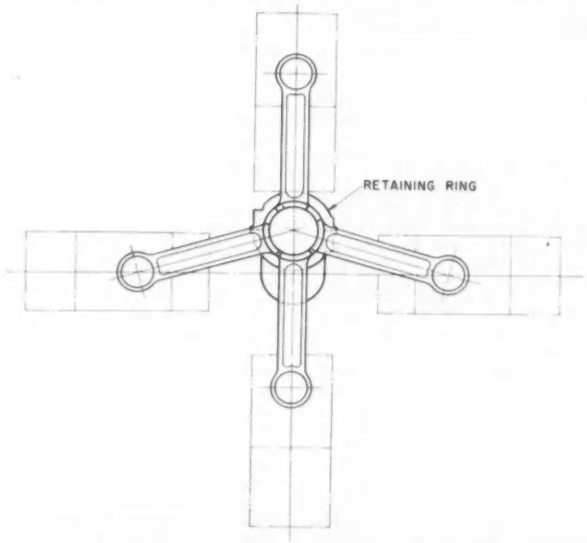


Fig. 1—Use of slipper-type bearings permits four connecting rods to be attached to a single crankpin

EXCERPTS FROM PAPER BY

W. E. Thill

Federal-Mogul Corp.

BUT engine bearings last a long time only if they are properly installed and maintained. Good maintenance practices embody the principles of maintaining a round hole for a round shaft under proper oil clearance conditions. Cleanliness and care in assembling are particularly important.

One approach to the problem of proper installation of engine bearings is to consider the following points individually:

1. Is the housing into which the bearing is being assembled round, reasonably smooth, straight, and of proper size?
2. Does the new insert bearing have similar grooving and oil holes; is it of the proper materials, and the correct undersize for the replacement?
3. Is the shaft round, smooth and straight, and of correct size?
4. Is the oil clearance correct?
5. Will good clean oil be supplied to the bearings under pressure?

These are the major elements when confined to one engine bearing. Obviously when more than one bearing in a direct line is involved, alignment of the two or more bearings becomes an additional consideration.

Deviations from practical limits on any of these points can lead to trouble in the form of shortened bearing life or possible immediate failure, depending upon the degree of the deviation.

(Paper, "Maintenance Practices with Regard to Engine Bearings," was presented at SAE Annual Meeting, Detroit, Jan. 14, 1952. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

About

JOHN E. JARRELL has been elected president of Ross Gear & Tool Co., Lafayette, Ind. He has been executive vice-president, and moves to the top executive position after 26 years with the organization. During that period he has been associated at one time or another with its production, sales and administrative divisions. Jarrel is an engineering graduate of Purdue University.

BEECHER B. CARY has been named director of engineering and research, Standard Products Co., Cleveland. Cary, formerly vice-president of engineering and a director of Hayes Industries, has been associated with the automotive industries ever since his graduation from University of Michigan as an aeronautical engineer in 1930.

DAVID T. SICKLESTEEL has been appointed general manager of Borg-Warner's new Products Development Laboratory, a separate division responsible for carrying both defense and civilian items from the invention stage to actual production. Sicklesteel has been vice-president of engineering of Borg-Warner's Detroit Gear Division. . . . Assisting in the direction of the laboratory will be a five-man committee on which are four SAE members: **C. S. DAVIS**, Borg-Warner board chairman; **ROY C. INGERSOLL**, B-G president; **HOWARD E. BLOOD**, B-G vice-president; and **E. S. RUSSEY**, vice-president of B-G's Warner Gear Division.

THUR SCHMIDT has been named director of research and development for the Ingersoll Products Division of Borg-Warner Corp. Formerly he was assistant to the president. He will devote his efforts to development of new manufacturing processes, as well as of new products and markets.

ORRIN W. BARKER has been named chief engineer of Kearney and Trecker Corp., Milwaukee, Wis. Since 1936 he has been the company's assistant chief engineer, and prior to that was with Ingersoll Milling Machine Co. and Nash Motor Co. Barker's work has been chiefly concerned with bed type and special milling machine design and the application of hydraulics to machine tools.

S. L. BRADLEY is now vice-president in charge of sales at Ross Gear & Tool Co., Lafayette, Ind. **F. H. DAVIS**, formerly district sales manager, has been named sales manager of the company, a position formerly held by Bradley.

DR. JEROME C. HUNSAKER has been awarded the Wright Brothers Memorial Trophy for 1951. The award, established 4 years ago by the National Aeronautic Association, is given for "significant public service of enduring value to aviation in the United States." Dr. Hunsaker is profesor of aeronautical engineering at Massachusetts Institute of Technology.

RAYMOND P. VINCENT is now in the United States as designer-engineer for Euclid Road Machinery Co., Cleveland, Ohio. He was formerly chief draftsman for Euclid (Great Britain) Ltd. in Lanarkshire, Scotland. Vincent is engaged in the design and development of rear-dump carrying equipment.

ALBERT J. BLACKWOOD, assistant director of research, Standard Oil Development Co., has been appointed to the subcommittee on aircraft fuels of the National Advisory Committee for Aeronautics.

HOWARD A. OFFERS is now at company headquarters in Bristol, Conn., as assistant sales manager of GM's New Departure Division. Previously he had been in Chicago as the Division's Midwest manager.

BEN F. HOPKINS, chairman of the board of Cleveland Graphite Bronze Co., and **JAMES L. MYERS**, president, have announced the acquisition by the Cleveland Graphite Bronze Co. of the Brush Development Co., Cleveland research and manufacturing organization widely known in the fields of electronics and technical instruments.

Members

ROGER M. KYES (right), vice-president of General Motors Corp. and general manager of GM's Truck and Coach Division, was recently elected chairman of the Sponsoring Committee of the Future Farmers of America. Kyes was one of the early supporters of the Future Farmers. Here Kyes is shown making plans for the 1953 FFA Foundation program with FFA National President Donald Staheli of Hurricane, Utah.

MAX EPPS, who has been chief automotive engineer for General Petroleum Corp., Los Angeles, Calif., has received a new assignment in that company's marketing department. His title will be fuels consultant.

F. P. BAEYERTZ succeeds **MAX EPPS** as chief automotive engineer of General Petroleum Corp. With the company since 1944, Baeyertz has been engaged chiefly in the engineering phases of marketing training. Previously he had been in industrial engineering and lubrication sales work.

J. F. BACHMAN, manager of Ford Motor Co.'s industrial engine department, has been elected treasurer for 1952 of the Internal Combustion Engine Institute.

S. WYMAN ROLPH, president of Electric Storage Battery Co., Philadelphia, has been elected president of the Franklin Institute. He is the 18th president of the 128-year-old organization, founded to promote and encourage invention and research in mechanics and applied science.

MAJ. WALTER C. FEATHERSTON is now overseas as division ordnance supply officer for the 20th Armored Division of the Army. Major Featherston was formerly chief of the automotive branch of the Ordnance School at Aberdeen Proving Ground, Md.

E. J. FOLEY is now offering his services as resident liaison representative and engineering and sales consultant to aviation and non-aviation industrial clients. His office is at 9619 Glencrest, Kensington, Md. For the past 18 months, Foley has been eastern region manager for Gordon D. Brown and Associates, with headquarters in Washington, D. C. Previously he served for 5 years as assistant to the vice-president of American Airlines in the Washington administrative office.

H. S. CURRIER has retired from active participation in vehicle engineering work after nearly 40 years in the automotive industry. Currier, who has also been with Cadillac, White Motor Co., Studebaker, and Oldsmobile, has most recently been Ford car engineer for Ford Motor Co. He will continue to live at 14961 Warwick Ave., Detroit.

GLENN C. BOYER has joined Phillips Petroleum Co., Bartlesville, Okla., as staff engineer in the combustion and lubricants branch of the research and development division. Boyer was formerly chief mechanical engineer for Frank Horton and Co. in Lamar, Mo.

CLARENCE WILLIAM LAUBIN is now staff powerplant engineer at Kaman Aircraft Corp., Windsor Locks, Conn. Until recently, he was chief engineer, Fredric Flader, Inc., North Tonawanda, N. Y.

NORMAN E. BRIGGS has been moved to Ohio as Dayton representative of the Fairchild Engine Division of Fairchild Engine & Airplane Corp. of Farmingdale, L. I., N. Y. Until last December he was the Division's chief test engineer.

J. H. SHOEMAKER since the beginning of this year has been devoting his entire time to his interests in the Kolene Corp., Detroit, Mich., of which he is president. Kolene originates and supplies chemical processes and equipment. Shoemaker has resigned as executive secretary of the Leaf Spring Institute, after 18 years in that position.

B. R. TEREE, chairman of SAE Committee A-6, Aircraft Hydraulic and Pneumatic Equipment, and chief engineer of the Weatherhead Co., Cleveland, Ohio, has been elected Associate Fellow of the Aeronautical Society of England as of Jan. 17.

WALTER L. DRAY is now executive engineer with Pioneer-Central Division of Bendix Aviation Corp., Davenport, Iowa. He was previously assistant engineering manager of Elgin National Watch Co. at Elgin, Ill.

HARRY O. HILL, who was a partner in Hill-Johnson Engineering Co. in Lansing, Mich., is now associated with American Bosch Corp. as manager of the Cleveland, Ohio, branch.

THEO F. SHARP is now assistant to the general manager of the Products Development Laboratory of Borg-Warner Corp., Detroit. Sharp's duties involve specifying materials and treatments for all new designs and supervising the engineering procurement department, the engineering garage, the machine shop, the mechanical testing laboratory and the engineering office. He was previously metallurgical engineer for Borg-Warner's Detroit Gear Division.

CHARLES W. ADAMS has been manager of quality control and processing at Heli-Coil Corp., since he left Watervliet Arsenal last fall. At Heli-Coil in Danbury, Conn., Adams has direction of process engineers, standards and methods, as well as of all phases of quality control and inspection. The company makes thread inserts.

HELMUTH G. BRAENDEL has been promoted from chief engineer to director of engineering and production at Wilkening Mfg. Co. in Philadelphia. He has read a number of papers before SAE audiences and has been active in the Diesel Engine Manufacturers Association.

MILTON L. GEARING, recently resigned as general manager of GM's New Departure Division, plans to enter business for himself after completing a vacation in Florida. At the time of his resignation, Gearing had completed 28 years of service with New Departure, having joined it in 1923 following his graduation from Rensselaer Polytechnic Institute.

PAUL W. ROGERS has been promoted to the newly-created post of assistant chief engineer of the Ohio Fuel Gas Co., Columbus, Ohio. Rogers has been with Ohio Fuel since 1933, except for service in the European Theater during World War II, when he attained the rank of lieutenant colonel. He has most recently been superintendent of motor transport for the fuel company

L. H. KLINE has been named materials control supervisor of the Gabriel Co. He has been a sales engineer for this Cleveland organization, and, more recently, controlled materials coordinator for its Ward Products Division. He is currently chairman of the Antenna Section of the Radio-Television Manufacturers' Association.

C. HARRY NYSTROM has been appointed assistant chief engineer of the fuel injection engineering department at American Bosch Corp., Springfield, Mass. For several years Nystrom has been a section engineer in charge of special projects. Last year, he was regional vice-chairman of the SAE Southern New England Section.

WILLIAM LITTLEWOOD, vice-president of engineering, American Airlines, completed 25 years of service with that organization on March 1. A group of associates and friends honored the occasion on Feb. 27 with an informal party in his honor and presentation of a plaque signalizing his quarter century of service. Littlewood is an SAE Past Vice-President representing Air Transport Engineering.

WILLIAM G. SEARLES is now design engineer in the New Holland Machine Division of Sperry Corp. at New Holland, Pa. His new position involves design of power-driven farm machinery, as did his previous work as design engineer at Massey-Harris Co., Racine, Wis.

PAUL B. HARTZKE is superintendent of maintenance for the St. Louis County Transit Co. He previously held the same position for Ben Gutman Truck Service in St. Louis.

MAURICE GOLDFINGER is now at Fairchild Aircraft Corp., engine division, Farmingdale, N. Y., as Air Force resident quality control representative. Goldfinger was formerly assistant representative at Lycoming-Spencer Division of Avco Mfg. Co.

ROBERT M. SWEARINGEN has been transferred to the Detroit office of Perfect Circle Corp. as sales engineer, manufacturers' sales. He was previously at the company's main offices at Hagerstown, Ind.

JACK C. HEDGE has been appointed assistant engineer in the heat-power department at Armour Research Foundation of Illinois Institute of Technology. Since 1948, Hedge had been with General Motors Corp., most recently as experimental test mechanic for the Electro-Motive Division. Previously he was graduated in mechanical engineering from Illinois Tech.

FRED W. ZELLMER, who was with the Civil Aeronautics Administration in Seattle, Wash., has been transferred to San Francisco as safety adviser, maintenance, in the CAA's International Region.

A new edition of **LESTER C. LICHTY'S** well-known text, "Internal-Combustion Engines," has been published by McGraw-Hill. The volume has been thoroughly revised to take account of recent developments, the more difficult parts have been simplified, and some old material has been eliminated to allow for the addition of new data.

Important changes include the following:

1. Addition of the Lenoir and Brayton cycles because of the development of jet, turbine, and rocket engines.
2. Amplified treatment of throttling and supercharging.
3. An analysis of back pressure with exhaust gas turbines.
4. Development of the analysis of jet thrusts from exhaust stacks of reciprocating engines and from other jet devices.
5. New material on fuels, mixture formation, icing, preflame reactions, knock, preignition, turbulence, combustion-chamber design, and fitting a fuel injection system to a given combustion chamber.

RUSSELL A. ANDERSON, who was formerly industrial engineer for the U.S. Government, has been appointed field service representative in Tokyo, Japan, for the far eastern division of Willys-Overland Export Corp.

BERNARD E. CARLSON, who was chief engineer of Superior Separator Co., Hopkins, Minn., is now in Pomona, Calif., with Farmhand Co., a newly acquired division of Superior.

VICTOR MILLMAN is now with McDonnell Aircraft Corp., St. Louis, Mo., as design engineer on helicopter test facilities. He was previously with Sverdrup and Parcel, Inc., in St. Louis.

DAVID R. OSBORNE has joined Bigelow Sanford Carpet Co., Thompsonville, Conn., as production engineer. He was formerly chief designer for Indian Motorcycle Co., Springfield, Mass.

DONALD E. KIEFERT, who was design engineer for Harnischfeger Corp., now holds the same position for the tractor engineering department of Allis-Chalmers Mfg. Co., Milwaukee, Wis.

LT. COL. SIDNEY G. HARRIS, USAFR, has been recalled to extended active duty with the Air Force and is now stationed at headquarters, 2274th Air Base, Wolters Base, Mineral Wells, Texas. Harris had been products manager for graphite and aluminum of Joseph Dixon Crucible Co. During World War II he was petroleum specialist for the Army, and was previously associated with Continental Motor Corp., Macmillan Petroleum Corp., and Petroleum Solvents Corp. He is a past chairman of Metropolitan Section.

GEORGE E. ROWBOTHAM is now technical assistant of the design and standards department, manufacturing staff, of Ford Motor Co. He was formerly assistant section supervisor of the engineering standards, illustrations and technical data section of the engineering staff.

JAY C. BELL has been promoted to assistant automotive powerplant engineer for Willys-Overland Motors, Inc., Toledo, Ohio. He was previously powerplant project engineer.

DONALD E. WITKIN has joined Power Generators, Ltd., Trenton, N.J., as analytical engineer. Witkin was previously an instructor in mechanical engineering at General Motors Institute.

EDWARD M. BROWN is now in the U.S. Army at Camp Grafton, Devil's Lake, N.D., as project engineer in the transport vehicles branch of the Ordnance Corps. Before joining the Army, Brown was assistant project engineer for Chrysler Corp.

RAY L. MORRISON, executive vice-president of DeVilbiss Co. has been elected president of the Northwestern Ohio Industrial Council. The Council was organized in 1950 as a fact-finding and evaluating organization for the diversified industries in the Toledo area.

R. WAINE THOMAS has been elected president of the Internal Combustion Engine Institute for 1952. He is vice-president and chief automotive engineer of Continental Motors Corp. The Institute collects and disseminates data on the internal combustion engine industry.

Nuttila Wins Ski Laurels . . .

MATT NUTTILA tied last year's champion in the downhill event of the New York City interclub ski races at Peekamoose Trail, Highmount, N. Y., on March 1. He represented the New York Ski Club in this fourteenth annual event which attracted a record entry of 105. Fifteen clubs took part. Both Nuttila and Jack Tobin of the Dartmouth Outing Club, who won the event last year, took 49.4 seconds for the course.

Nuttila, who is superintendent of motor vehicles, Cities Service Oil Co., and a member of the SAE Technical Board, started skiing as a boy in Northern Michigan, where he was brought up. Back there, in fact, he once won a cord of wood as a ski race prize. But after getting out of high school, he almost abandoned the sport until 1939. Since then skiing has been a favorite winter sport again.

Meade F. Moore

N. Erik Wahlberg

MEADE F. MOORE has been elected vice-president in charge of research of Nash-Kelvinator Corp., following 15 years as chief engineer of research for the corporation. From 1926 to 1937, Moore was chief engineer of various Nash plants in Milwaukee, Racine, and Kenosha, Wis. He has been with Nash ever since 1917, the year in which he joined SAE. He participated in engineering the first Nash cars.

N. ERIK WAHLBERG, completing a distinguished automotive career extending over 44 years, retired as vice-president in charge of Nash engineering at Nash-Kelvinator Corp. late in February. A member of SAE for 40 years, Wahlberg left General Motors in 1916 when Charles W. Nash resigned as president and became Nash's chief engineer when Nash bought the pioneer Thomas B. Jeffry Co.

EDWIN E. ENSIGN has become vice-president of the A.R.D. Corp., New York. Previously, he was a research metallurgist at Ford Motor Co. in Dearborn, Mich.

ROBERT V. McCALLISTER is now sales engineer for Glass Fibers, Inc., in New York City. He was previously with Electric Auto-Lite Co., Toledo, Ohio.

JACK E. GIECK is now associated with Firestone Industrial Products Co., Detroit. He was previously a technical writer for Chrysler's engineering division department of technical data and information.

J. ALEXANDER STEEVES is one of a group of Montrealers whose hobby is making toys for Christmas distribution to children in the city's hospitals and institutions. The group forms the Real Need of Happiness Toy Shops, and since its founding 12 years ago has turned out more than a quarter of a million toys with materials and money donated by members and friends. Steeves, who was formerly associated with White Motor Co. of Canada, has since last August been service manager of City Motors, Ltd., in Montreal.

C. W. SAWHILL is now industrial sales supervisor for Aero-Coupling Corp. in Burbank, Calif. He will supervise industrial sales, service and application engineering for the company in most of the territory west of the Rockies. Sawhill was previously sales engineer for Aeroquip Corp. in Jackson, Mich.

JOSEPH PROSKE is now associated with Burgess-Norton Manufacturing Co. in an engineering capacity. He will be particularly concerned with research and development incident to tracks and track-laying vehicles.

Proske went to his new post shortly following his retirement as chief engineer, product engineering, Ordnance Tank Automotive Center, Detroit, after 41 years of service in various Ordnance armories. Co-designer of the new General Walker tank, Proske began his career at the Rock Island Arsenal at the age of 17.

ERNEST D. GROCOCK has been appointed as instructor in agricultural engineering at California State Polytechnic College. He went to his new post on March 15 from Melfort, Saskatchewan, Canada, where he had been associated with Melfort Motors, Ltd., distributors of tractors and farm implements.

WILLIAM A. ROBERTS, president, Allis-Chalmers Mfg. Co., went back on Feb. 14 to Strafford, Mo., for homecoming day at the elementary school from which he graduated in 1914. He delivered the chief address at the banquet at which he was an honor guest, having been a member of the first class to be graduated from Strafford Reorganized School, District No. 6.

A new edition of "The Automotive Chassis" has been published by its author, **P. M. HELDT**. This volume, which was first published in 1945, is now in its third edition. New material has been added, particularly to the chapters: "Chassis Types and Layouts," "Power Required for Propulsion and Acceleration," "Frames and Their Brackets," "Brakes," and "Power Brakes and Auxiliary Energy Dissipators." The book is available from P. M. Heldt, Nyack, N.Y.

RUSSELL W. GAMAGE has joined Sverdrup and Parcel, Inc., St. Louis, Mo., as senior aeronautical engineer. Gamage is working on the design of aerodynamic test facilities at the Arnold Engineering Development Center at Tullahoma, Tenn. He was previously senior aerodynamicist for the research department of United Aircraft Corp.

ALLEN W. ROMIG of Harper Engineering Co. has now returned to Pennsylvania to work on powerplant design for Kaiser Metal Products' aircraft division. He was previously working for Harper at Lockheed Aircraft Corp. in Burbank, Calif.

Obituaries

ALANSON P. BRUSH

Alanson P. Brush, a member of SAE since 1906, died in Detroit at the age of 74 on March 6.

Fifty years ago, Brush drove a one-cylinder Cadillac up the front steps on the County Building in Detroit—and down again.

Then he designed the Brush runabout, one of Detroit's first light-model cars. Later he organized the Oakland Motor Car Co., which subsequently became a division of General Motors Corp.

When that happened, Brush became chief engineer of Buick. During the last 20 years of his life, he was active in the field of patent law as an expert witness.

In addition to his fame as an automotive pioneer, Brush served in the Spanish-American War in the 31st Michigan Regiment. He was a member of the Detroit Boat Club and the American Society of Mechanical Engineers, as well as of SAE.

MELVIN E. VAN SICKLE

Melvin E. Van Sickle, sales engineer of General Motors' Delco Radio Division, died on Jan. 25, 1952.

During World War II, Van Sickle shifted from Delco to Fisher Body Division. There he was an assistant supervisory engineer on some aircraft structure products with which Fisher was engaged at that time.

He first joined the General Motors organization in 1933 when he took part in automobile radio and electrical equipment engineering development work with General Motors of Canada at Oshawa. His earlier work was Kolster Radio, Inc., in Newark and Toronto.

He was a native of Newcomerstown, Ohio, where he was born in 1901. He went to high school there, and later studied radio theory at the National Radio Institute in Washington, D. C. Then he took electrical engineering for two years at the Newark Technical Institute in Newark, N. J.

STUDENTS ENTER INDUSTRY

JOHN WILCOCK (McGill University '51) is a mechanical engineer with Dominion Tar & Chemical Co., Ltd., Montreal, Canada.

JOSEPH M. BROWN (Purdue University '51) is a research engineer with North American Aviation, Inc., Downey, Calif.

RICHARD J. MATT (Case Institute of Technology '51) is with United States Rubber Co., Detroit, as a development engineer.

ARTHUR H. CROFT (Northrop Aeronautical Institute '51) is a draftsman for Northrop Aircraft, Inc., Hawthorne, Calif.

BRUNO M. LARSEN (West Coast University) has been recalled to active duty as a lieutenant in the U. S. Air Force.

ROBERT C. BROOKS (California State Polytechnic College) has been recalled to the Army and is a test engineer in the engineering research and development laboratory at Fort Belvoir, Va.

LEONARD EDELSTEIN (West Coast University) has been recalled to duty with the Navy.

NELSON E. SMITH (Aeronautical University '50) is an aerodynamist in the parachute Branch at Wright-Patterson Air Force Base, Dayton, Ohio.

HOWARD E. DAHL (Illinois Institute of Technology '50) is with Carr & Wright, Chicago, Ill., as assistant superintendent of construction.

JOHN D. YOUNG (Purdue University '50) has joined Link-Belt Co., Indianapolis, Ind.

JACK K. GILBERT (Oklahoma A&M College '50) is medical equipment maintenance officer at the Army's St. Louis Medical Depot, St. Louis, Mo.

RICHARD H. FRANCE (University of Wisconsin '49) has completed graduate work at Chrysler Institute and is a junior engineer at Chrysler's Newark Tank Plant, Newark, Del.

JAMES W. NOLAN (Purdue University '50) has joined Peerless Pump Division of Food Machinery and Chemical Corp., Indianapolis, Ind., as an application engineer.

HAROLD W. FODDY, JR. (University of Colorado '50) is a motor transportation supervisor in the U. S. Air Force at Bartlesville, Okla.

LOWELL M. MILLER (University of Minnesota '50) is a research engineer in the aerophysics department of North American Aviation Corp., Downey, Calif.

HAROLD N. WEINBERG (University of Florida '50) received his master of science degree from the University last spring and is now a 2nd lieutenant at the Army's transportation research and development station, Fort Eustis, Va.

CORNELIUS J. FITZGERALD, JR. (Indiana Technical College '50) is with the Army's 32nd Engineer Construction Group as chief engineer.

LYNN CECIL PURSELL, JR. (California State Polytechnic College '50) is an aeronautical engineer at McClellan Air Force Base, Sacramento, Calif.

FRED J. WEIR (Northrop Aeronautical Institute '50) is with the Air Force in Korea. Sergeant Weir is a gunner on a Douglas B-26 light bomber.

FRED W. ABERLE (Northrop Aeronautical Institute '49) is a draftsman for North American Aviation, Inc., Los Angeles, Calif.

GERALD G. BORUSKI (University of Minnesota '50) is a student officer in pilot training at Reese Air Force Base, Texas.

DENNIS J. HAYMAN (Detroit Institute of Technology '50) is a detailer on product design in the Hydraguide laboratory of Gemmer Mfg. Co., Van Dyke, Mich.

HARVEY J. LANDER (University of Massachusetts '50) is a liaison engineer for Hamilton Standard Division of United Aircraft Corp., East Hartford, Conn.

MORRIS SCHULMAN (University of Colorado '50) is a mechanical engineer for the U. S. Naval Engineering Experiment Station, Annapolis, Md.

CECIL L. COTTON (University of Oklahoma '50) is a service engineer on jet engines with General Electric Co. in Oklahoma City, Okla.

DELMAR L. BOECK (Tri-State College '50) is with South Wind Division of Stewart-Warner Corp., Indianapolis, Ind., as a test equipment engineer.

REGINALD A. PARSONS (California State Polytechnic College '50) is a design draftsman in the vessels department of Foster Wheeler Corp., Houston, Texas.

HAROLD FORD SMITH (Parks College '50) is in the manufacturing control department of Northrop Aircraft, Inc., Hawthorne, Calif.

HOWARD J. HUTSELL (Indiana Technical College '49) is with Indiana Gear Works, Indianapolis, Ind., in the production control department.

CLYDE C. CULVER (Michigan State College '50) is an engineer at General Motors Proving Ground in Lansing, Mich.

KENNETH W. NEUDECK (University of Colorado '50) is on active duty with the Air Force. Captain Neudeck is maintenance squadron armament officer with the 116 Fighter-Bomber Wing.

FREDERICK A. STEWART (Chrysler Institute '50) is a laboratory engineer for Chrysler Corp. at Highland Park, Mich.

EDMUND J. WAYNE (Lawrence Institute of Technology '50) is with Ford Motor Co., Dearborn, Mich., as an automotive detailer draftsman.

KENNETH N. UNGER (Illinois Institute of Technology '50) is in design analysis with International Harvester Co., Melrose Park, Ill., while attending graduate school part-time.

RAYMOND A. SWANSON (Tri-State College '50) is a test engineer in the product group of Hamilton Standard Division of United Aircraft Corp., East Hartford, Conn.

EDWARD M. SMITH (Purdue University '49) has received his master's degree from the University of Minnesota and is now with Ethyl Corp., N. Y. C.

ROSS G. HOLT (Michigan State College '51) is now with the Picatinny Arsenal at Dover, N. J.

JOSEPH LEVITT (Polytechnic Institute of Brooklyn '50) is a research engineer for M. W. Kellogg Co., Jersey City, N. J.

PAUL A. LINK (Illinois Institute of Technology '51) is general foreman at the malleable foundry of National Malleable and Steel Castings Co., Cicero, Ill.

CHARLES H. S. BUTLER (Cornell University '51) is a junior engineer with E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

TECHNICAL COMMITTEE *Progress*

E-25 Studies Fatigue Life Of Carbon-Restored Bolts

EFFECT of restoring carbon lost in processing bolt wire on fatigue life of bolts is under investigation by the SAE Aircraft Engine Division's Committee E-25.

Chairman J. D. Clark accepted the offer a bolt supplier made at the February 19 meeting to have blanks produced and to ask Leeds & Northrup to restore the carbon in their new Microcarb equipment. After carbon restoration, the blanks will be heat-treated and the threads rolled. Fatigue life will be determined in tension testing.

Committee E-25 intends to use the fatigue-test results as a guide in deciding whether or not to recommend to the Aeronautical Materials Division that the Aeronautical Materials Specifications called out in the six-digit bolt standards shall recognize that a carbon-restoration process may be applied or whether such processes shall be ruled out. At present, the AMS called out in the bolt standards do not mention carbon restoration, but there is some feeling in the industry that they might be interpreted to allow it.

For aircraft engine and propeller quality bolts, grinding is the method conventionally used to remove the decarburization, which is formed on the hot billet and carried on the surface of the stock down through the rolling operations to the bolt or stud blanks. The disadvantage of the grinding method is that it is expensive, costing as much as 12¢ per bolt in some cases. More important, in wartime there might not be enough centerless grinders available in the country to meet the increased demand for high-quality bolts and studs.

Until recently, available carbon-restoration methods were considered not sufficiently accurate to insure restoration within the close limits required by the bolt-material AMS. The new Microcarb controlled-atmosphere equipment, it was reported to E-25, can reliably control carbon content to within ±0.05% of the set value uniformly from the surface of the blank inward. A supplier added that, as far as he knew, no bolt manufacturer now owns the new equipment, but he indicated that bolt makers, like the users, are interested because of the lower manufacturing cost that may be possible.

The question in some users' minds of the effect on fatigue properties of carbon restoration by the carefully controlled equipment stems from a point W. P. English brought up several months ago. He pointed out to the AMS Division that carbon restoration, if it is to be practiced, should be applied before heat-treatment and thread rolling. Otherwise, the high restoration temperature—which may be even higher than the heat-treating temperature—destroys the desirable prestress in the rolled threads.

English's comment led some bolt users to seek proof of whether carbon restoration can be controlled accurately enough to insure maximum fatigue life. They reported at E-25 meetings that some carbon-restored bolts have already been offered at attractive prices to engine manufacturers. Users point out that they might even accept carbon-restored bolts without realizing it because the condition usually cannot be detected in the finished bolt. They'll be glad to use bolts with carbon restored so accurately that fatigue life and other desirable characteristics are insured, but they want to be certain first that the process is that reliable.

Proposed ASA Standards Of Screw Threads, Bolts

PROPOSED revisions to two ASA Standards and one proposed ASA Standard have been approved by the SAE and the ASME, as sponsoring societies, and have been recommended to the ASA for adoption as American Standards:

1. ASA B1—Acme Screw Threads: proposed revision of the American War Standard B1.5-1945 for Acme Threads.
2. ASA B1—Stub Acme Screw Threads: a proposed new American Standard.
3. ASA B18.5 Round Head Bolts: a proposed revision of ASA B18.5-1939. Its new features include introductory notes (which give thread form and length, bolt length and tolerance, and other manufacturing details) and the addition of four new forms of round head bolts: short, square neck bolts, flat and ribbed head countersunk elevator bolts, and T-head bolts.

The work on the Acme screw threads was done by subcommittee 2 of the ASA Sectional Committee B1 on Standardization and Unification of Screw Threads, and that on the round head bolts by subcommittee 5 of the ASA Sectional Committee B18 on Dimensional Standardization of Bolts, Nuts, Rivets, Screws, and Similar Fasteners.

SAE representatives on B1 are: Earle Buckingham, M.I.T.; P. L. Houser, International Harvester Co.; Gustaf Carvelli, Wright Aeronautical Corp.; and H. A. Marchant (deceased), Chrysler Corp.

SAE representatives on B18 are: W. L. Barth, GMC; R. R. Burkhalter, Spicer Mfg. Division, Dana Corp.; R. G. Cummings, Ford Motor Co.; H. A. Marchant (deceased), Chrysler Corp.; and K. G. Roth, Mack Mfg. Corp.

New Standard on Pipe, Hose Connections

A STANDARD on Hydraulic Flanged Tube, Pipe, and Hose Connections (4-Bolt Split-Flange Type) has been approved by the SAE Technical Board.

This standard, developed by the SAE Tube, Pipe, Hose, and Lubrication Fittings Committee, is for fittings designed for industrial hydraulic installations, where it is desired to eliminate threaded connectors. The general specifications are identical with those for SAE Industrial Hydraulic Tube (37-deg flare) and Hose Fittings. Nominal flange sizes from ½ in. to 2 in. are covered.

Other work in progress by this committee includes revisions of the present SAE Standard on Refrigeration Fittings, which is being done by a subcommittee with J. E. Gray as chairman.

Military May Accept Plane Control Standards

WELL on the way toward its final form is a report on the location and actuation of cockpit controls for commercial multiengine transport aircraft—and possibly for military ones, too. This report is the work of the controls subcommittee of Committee S-7 (Cockpit Standardization) of the SAE Special Aircraft Projects Division.

Its development was requested by the Air Transport Association and the Aircraft Industries Association about a year and a half ago. These groups considered that several advantages might accrue if all multiengine aircraft could be built to the same standard, as far as cockpit controls were concerned. There is the possibility of reducing pilot errors as well as pilot transition time, pilot fatigue, and other factors detrimental to flight safety.

During this period the military services were also developing standards of their own, which, it was realized, industry would have to meet in military contracts.

Meanwhile, though, the military invited members of Committee S-7 to a meeting, at which it was hoped that differences between the two standards could be reconciled. At this conference, which was held in February of this year, the military representatives announced that the commercially developed standards would meet their requirements if only 20 changes were made, all but two of them minor.

The main points of dissension are the following:

1. Location of landing gear and flap controls.

2. Operation of switches and controls on overhead panels.

An example of a minor difference is that S-7 had recommended that a bell be used as a warning for fire, but to military people a bell means "bail out."

In view of the advantages to be gained by having the commercial and military standards contain the same philosophy and technical data and particularly since both standards are already so close together, the AIA has asked the CAB to extend the deadline when the standard must be developed (originally April 1) to some date that would allow sufficient time to permit full coordination between the military and Committee S-7 in the development of a common standard for military and civilian aircraft. Meanwhile, R. L. Thoren, chairman of the controls subcommittee, has called a meeting of S-7 to consider the changes that will be needed to meet the military requests.

R. L. Thoren, chairman of controls subcommittee of Committee S-7 (Cockpit Standardization) of the SAE Special Aircraft Projects Division

Navy Finds Better Way To Recheck Torsiographs

THE Brookyln Navy Yard has come up with a new way of calibrating torsiographs, instruments used for measuring torsional vibration of engines. This new method is an extension of the work discussed in the SAE Special Publication—Cooperative Testing of Torsiographs and Caligraphs.

According to the co-authors of the Navy report, William H. Knopfle and Milton J. Berg, up to now torsiographs had to be calibrated with similar equipment. It's like having to check the distances on a ruler with other rulers. The two Navy engineers have come up with a completely independent method of calibration using electronic equipment.

The basic reports on torsional vibration, refered to in the Navy investigation are available from SAE. The price of "Evaluation of Effects of Torsional Vibration" is $5.00 to members and $10.00 to nonmembers; and that of "Cooperative Testing of Torsiographs and Calibrators" is $3.00 to members and $6.00 to nonmembers.

New Volume Storehouse Of Heat Transfer Data

A UNIQUE source of data on the thermal properties of materials is now available. In the form of a new SAE Aeronautical Information Report, it marks the first time that such a wide variety of data have been collected under one cover.

Most of these data are arranged to show the thermal properties of various solids, liquids, and gases. Some of it, however, is included in sections which treat with the theoretical phases of heat transfer. Here can be found numerous graphs, tables, and equations—systematically arranged for straight-forward use.

Usefulness of this material is not limited to aircraft applications. It can be applied equally well to almost any heat transfer studies and fluid flow problems.

Among the major subjects covered in this 250 page volume are:

- General physical properties
- Thermal conductivity data
- Specific heat, viscosity, and density data
- Basic conduction, convection, and radiation equations
- Typical aircraft heat transfer conductances

The job of assembling and compiling this extensive information was done by a Committee A-9 group, led by Lockheed's B. L. Messinger. (Committee A-9, Aircraft Air Conditioning Equipment, is in the Accessory and Equipment of the SAE Aeronautics Committee.)

The report, entitled AIR 24, can be obtained from the SAE Aeronautics Department. Price: $4.50.

Lockheed's B. L. Messinger was chairman of the the A-9 group which prepared the new 250 page volume of heat transfer information

New Finish Gage

A. F. Underwood, GM Research Laboratories Division, and chairman of SAE Surface Finish Committee (left), and Dr. Clayton Lewis, Chrysler Corp., examine the new surface finish roughness specimen that is now being made commercially available to industry. The gage has five roughness height values which conform with the SAE Surface Finish Standard.

AISI Fixes Hardenability Band Limits for TS50B60H and TS81B40H Steels

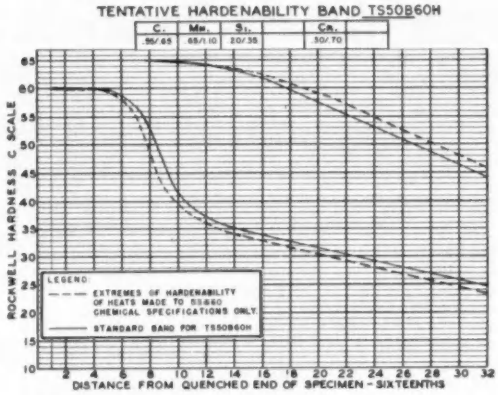
HARDENABILITY-band limits for TS50B60H and TS81B40H developed by the American Iron and Steel Institute, have been approved by the SAE Iron and Steel Technical Committee.

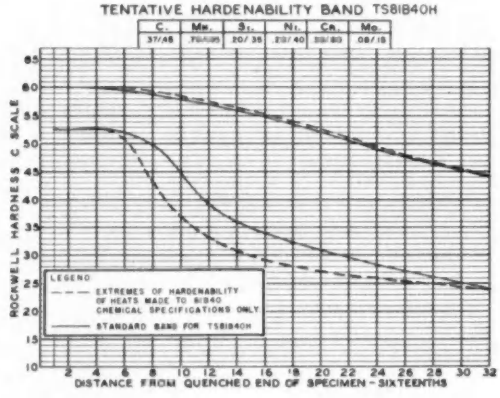
The limits for the two AISI Tentative Standard steels are reproduced in the accompanying charts and tabulated in Table 1.

Table 1—End-Quench Hardenability Bands[a] for TS50B60H, TS81B40H

"J" Distance, in.	Grade			
	TS50B60H		TS81B40H	
	Max	Min	Max	Min
1/16	—	60	60	52
1/8	—	60	60	52
3/16	—	60	60	52
1/4	—	60	60	52
5/16	—	60	60	52
3/8	—	59	60	52
7/16	—	57	59	51
1/2	65	53	58	50
9/16	65	47	58	47
5/8	64	42	58	44
11/16	64	39	57	41
3/4	64	37	57	39
13/16	63	36	56	37
7/8	63	35	56	36
15/16	63	34	55	35
1	62	34	55	34
1 1/8	60	33	54	32
1 1/4	58	31	52	31
1 3/8	55	30	51	29
1 1/2	53	29	49	28
1 5/8	51	28	48	27
1 3/4	49	27	46	26
1 7/8	47	26	45	25
2	44	25	44	24

[a] These values are adjusted to the nearest Rockwell "C" point and are used when points are selected and specified.


TENTATIVE HARDENABILITY BAND TS50B60H
C. 55/65
Mn. 65/1.10
Si. 20/35
Cr. 50/70
ROCKWELL HARDNESS C SCALE
LEGEND
EXTREMES OF HARDENABILITY OF HEATS MADE TO SI840 CHEMICAL SPECIFICATIONS ONLY
STANDARD BAND FOR TS50B60H
DISTANCE FROM QUENCHED END OF SPECIMEN - SIXTEENTHS



How NPA Allots Alloys Explained at Meeting

STEEL producers bear much of the responsibility for conservation of scarce alloying elements under the National Production Authority's current procedure for handling steel orders. This was brought out at the December 4 meeting of Division VIII-Boron Steels of the SAE Iron and Steel Technical Committee.

According to information presented at the meeting, each steel producer is told in advance how much nickel and molybdenum he will be allowed to use per month. This figure is based on past practice and NPA's estimates of the availability of the alloying elements in question. Steel producers then make up melt schedules tailored to meet the figures for nickel and molybdenum previously given to them.

This puts a large portion of the burden of conservation directly on the steel producer. Div. VIII participants were told, for the leaner the steels the producers melt, the more steel they can produce with a given amount of nickel and molybdenum. An inquiry or order received by a producer from a consumer is, therefore, considered carefully in the light of Metallurgical Branch's indications of grades available for particular end-uses. If the end-use does not seem to justify the alloy content specified, the producer suggests an alternate grade to the consumer. If the consumer is persuaded, the order is written up accordingly and appears on the melt schedule. More than likely, the order will be approved by the Metallurgical Branch of NPA's Steel Division.

If the producer cannot persuade the consumer to accept the leaner-alloy grade, the producer enters the higher-alloy grade on the melt schedule. But the higher-alloy grade stays on the melt schedule only if the Metallurgical Branch approves it.

The timing of an order has a lot to do with whether or not the steel producer accepts it, particularly if the order is for a grade containing nickel or molybdenum. An example cited was that of a customer who on November 8 ordered a nickel-molybdenum

grade for delivery in January. The steel had to be melted in December, but the steel producer had had to submit his schedule for December melting to NPA by November 7. After that date, the producer could obtain more nickel or molybdenum only by an NPA directive.

Since the producer did have the capacity to melt steel in December and roll it in January, he offered the consumer a grade containing no nickel or molybdenum. The consumer agreed. Then the producer had to prepare a supplementary melt schedule for approval by the Metallurgical Branch.

Warning was given that the timing of an order might have this result, even though on inquiry in October the producer had recommended an AISI Tentative Standard steel containing nickel and molybdenum.

Preparing Manual On Blast Cleaning

PREPARATION of a manual on blast cleaning has been undertaken by the Blast Cleaning Subcommittee of ISTC Division XX.

Topics proposed for the manual include blast-cleaning machines; abrasives; parts preparation; masking; supporting fixtures; wheel spray and nozzle parttern; control of abrasive sizes, flow rate, and exposure time; ventilation; laboratory methods for testing; production control analysis; and inspection. The manual is intended for eventual issuance as an SAE Special Publication.

Among the subcommittee members writing various sections of the report are E. E. Alexander, K. H. Barnes, D. P. Buswell, T. F. Butler, R. S. Dahmer, J. F. Ervin, W. I. Gladfelter, F. R. Gladwin, C. J. Hellebush, W. L. Kann, R. L. Mattson, W. R. Naas, H. J. Noble, M. R. Wiard, and W. H. Woodcock.

G. F .Bush is chairman of the group appointed to collect the writings and edit them.

New Report Details Plane Heater Design

WAYS to design and test aircraft engine exhaust-gas-to-air type heaters are outlined in a new SAE Aeronautical Recommended Practice. Heaters for cabin, wing and empennage, engine, and accessory heating, alike—all are covered in this new package of engineering information.

Set forth are many recommended practices for designing and testing these heaters. Desirable design features, materials, workmanship—and even proper nameplate marking—all come in for attention. Described in detail also are suitable tests for determining performance qualities, vibration, life, leakage, and collapsing pressure of these heat exchanger units.

Prepared by Committee A-9, Aircraft Air Conditioning Equipment, of the SAE Aeronautics Committee's Accessory and Equipment Division, ARP 86A can now be obtained from the SAE Aeronautics Department.

Credit for developing this material goes to a task group of A-9. Project chairman James Conners, of Grumman, guided this work to completion. The project was started by Glenn L. Martin's R. J. Berner.

James Conners, of Grumman Aircraft, chairman of the A-9 group which developed the new SAE Aeronautical Recommended Practice on aircraft heaters

Technishorts . . .

ENGINE COOLANTS—The newly formed Subcommittee on Engine Coolants is studying corrosion inhibitors and corrosion problems due to the possible use of substitute materials in radiator construction. B. E. Tiffany is chairman of this subcommittee of the SAE Nonmetallic Materials Committee. J. M. Clark, R. A. Willhnganz, and H. R. Wolf are members.

HEADLAMP TESTERS—Comparative tests of commercial headlamp testers are scheduled for April 21 at the Electrical Testing Laboratories in New York by the Headlamp Tester Subcommittee of the SAE Lighting Committee. V. J. Roper is subcommittee chairman. The subcommittee is working on recommendations for the testers at the request of the Commercial Vehicle Inspection and Engineering Committee of the American Association of Motor Vehicle Administrators.

BRITISH NOTE SAE TERMINOLOGY—Noting that SAE published in March 1951 the SAE Recommended Practice on Hydrodynamic Drive Terminology, the British magazine "Automobile Engineer" says: "Whilst it does not seem proper that the British, who are the originators of the English language, should turn to America for their terminology, it does, however, seem highly desirable to standardize in this subject, and it is to be hoped that the British Standards Institution will take the matter up further in cooperation with both the SAE and British industry."

"Many papers have been, and will be published on hydrodynamic drives on both sides of the Atlantic, and it is most essential that . . . no confusion shall be caused by differences of terminology," the magazine emphasizes.

BESTSELLERS—Industry has purchased 6,400,000 copies of SAE Aeronautical Material Specifications since they were first issued in 1939, reports AMS Division Chairman J. B. Johnson. During 1951, 324 new and revised AMS were published, bringing the total published to 541.

WINCH USE DATA—A questionnaire asking for data on automotive worm gear winches is being sent out to users of this type of winch. Users will be asked to answer such questions as maximum length of continuous pulls, maximum speed, minimum time available between pulls for cooling, average number of pulls per work day, maximum weight held by winch line or pulled only a very short distance, and what they consider limiting factors in use. This information will then be analyzed by the Winch Rating Subcommittee of the SAE Transportation and Maintenance Technical Committee, and used as an aid in developing an SAE Standard for rating worm gear winches.

New Changes in SAE Standards . . .

THE following have recently been approved by the SAE Technical Board:

SEALED-BEAMED HEADLAMPS—Addition to the SAE Standard on Lamp Bulbs and Bases of a note to Fig. 5, (which shows the sealed-beam headlamp unit) that "To provide ample clearance for connectors and European-type units there shall be a minimum of 4.13 in. (105 mm) from the seating plane of the unit mounting ring to the inside of the lamp housing."

NAVAL BRASS—Deletion of SAE 76, Naval Brass Tubes, from the SAE Standard on Wrought Copper-Base Alloys.

STORAGE BATTERIES—In the SAE Standard on Storage Batteries, substitution of the paragraph

> "The fully charged initial specific gravity at the end of the conditioning charge should not be changed from the nominal specific gravity and electrolyte level specified by the manufacturer. If not so specified, the battery shall be tested with the specific gravity and electrolyte as manufactured."

for the paragraph "The fully charged specific gravity of the electrolyte level shall be 1.280 to 1.300 at 80 F, and the electrolyte level shall be not less than $\frac{3}{8}$ in. over the top of the separators unless otherwise specified by the manufacturer."

Reason for the change is that much experimental work aimed at longer battery life is in progress on batteries which when fully charged have an electrolyte specific gravity of less than the traditional 1.280–1.300. The Electrical Equipment Committee recommended the revision to facilitate development testing of the batteries, although battery manufacturers are not yet in complete agreement on overall advantages of the change in specific gravity.

RADIATOR FILLER NECKS—A new Standard on Radiator Filler Necks prepared by a subcommittee of the SAE Engine Committee.

WIRING—A revision in the SAE Recommended Practice on Automobile Wiring deleting the sentence "The use of crimped terminals shall be restricted to applications in the lighting circuits." This deletion was recommended by the Electrical Equipment Committee because of technical developments since the limitation was instituted.

INSULATED CABLE—Deletion from the SAE Standard for Insulated Cable of the note that "Because of the special care needed in processing small conductors, it is recommended that nothing smaller than No. 16 wire be use in the wiring harness." The Electrical Equipment Committee felt this note was no longer necessary because of improvements in termination applications.

Also in this standard, the specifications for conductors for braid-covered and for synthetic-sheathed high-tension cables have been revised to call for 7 or 19 strands (instead of just 19) of annealed tinned copper wire (instead of No. 29 AWG annealed tinned copper wire). An added stipulation is that the diameter of the stranded group shall not be less than 0.030 in.; the maximum diameter allowed remains 0.060 in.

ENGINE MOUNTINGS—A revised SAE Standard for Engine Mountings prepared by a subcommittee of the SAE Engine Committee.

STAINLESS STEELS—Revisions to the SAE Standard on Chemical Compositions of SAE Wrought Stainless Steels and the SAE General Information Report on General Characteristics and Heat-Treatments of Steels to divide the chromium steels into martensitic and ferritic groups and give more detailed information about them. The changes were approved by the SAE Iron and Steel Technical Committee.

TOOL AND DIE STEELS—Addition of an identification and classification system to the SAE Recommended Practice on Tool and Die Steels. The system is the work of the Tool and Die Steels Division of the SAE Iron and Steel Technical Committee.

Classification System For Tool Steels Ok'ed

A NEW system of classifying and identifying tool steels has been added to the SAE Recommended Practice on Tool and Die Steels.

The system divides tool steels into six major groups and assigns these letter symbols:

Water-Hardening Tool Steels	S
Shock-Resisting Tool Steels	O
Cold-Work Tool Steels	W
Oil-Hardening Types	
Medium-Alloy Air-Hardening Types	A
High-Carbon High-Chromium Types	D
Hot-Work Tool Steels	H
Chromium-Base Types	H1-H19
Tungsten-Base Types	H20-H39
Molybdenum-Base Types	H40-H59
High-Speed Tool Steels	
Tungsten-Base Types	T
Molybdenum-Base Types	M
Special-Purpose Tool Steels	
Low-Alloy Types	L
Carbon-Tungsten Types	F
Mold Steels, Low-Carbon Types	P1-P19
Mold Steels, Other Types	P20-P39

The classification is the fruit of several years of effort by Division XXVIII-Tool and Die Steels of the SAE Iron and Steel Technical Committee. In working out the classification, Division XXVIII had the cooperation of the American Iron and Steel Institute's committee concerned with tool and die steels and the American Standards Association's sectional committee on classification of tool materials. Now the SAE Technical Board has approved the resulting system, and it will be incorporated into the 1952 SAE Handbook.

Division XXVIII members include S. R. Prance, chairman; A. D. Beeken, Jr.; D. I. Dilworth, Jr.; D. J. Giles; A. S. Jameson; E. M. Lape; A. O. Mason; P. J. McCarthy; C. L. Stevens; L. A. Tyner; and H. H. ZurBurg.

New Reference Fuels Match Commercial Fuels

BLENDS of diisobutylene, isooctane, and n-heptane can be used as reproducible severity reference fuels by equipment builders and fuel suppliers in work involving either car octane number requirement studies or road octane number ratings.

This is the conclusion of CRC 261 "Severity Reference Fuels," a report

recently released by the Coordinating Research Council. The report is the work of the Severity Reference Fuels Panel of the Road Test Group working on detonation projects of CRC's Motor Fuels Division.

The report begins with an explanation of how diisobutylene came to be the hydrocarbon chosen to blend with the two primary reference fuels, isooctane and n-heptane. The rest of the report is concerned with data in support of the choice of diisobutylene. Included are 15 graphs comparing road test results with diisobutylene blends and with commercial fuels in the 1949 Road Rating Programs. The graphs show that diisobutylene blends, increasing in sensitivity with octane number level in the same manner as present commercial-type gasolines, give similar changes in road octane number with speed.

The report has twenty-one $8\frac{1}{2} \times 11$ in. pages. It is available at 75¢ to SAE members and $1.50 to nonmembers from the SAE Special Publications Department, 29 West 39th St., New York 18, N. Y.

Board Approves New Officeholders

THE SAE Technical Board has recently approved these new appointments and election results:

As Members of the Technical Board Executive Committee for 1952

P. C. Ackerman
R. D. Kelly
E. S. MacPherson
S. W. Sparrow

As Technical Board Sponsors for Technical Committees

P. C. Ackerman for the Automotive Drafting Standards Committee
A. F. Meyer, Jr., for the Construction and Industrial Machinery Technical Committee
E. S. MacPherson for the Electrical Equipment Committee
W. M. Walworth for the Engine Committee
P. C. Ackerman for the Nonferrous Metals Committee
S. W. Sparrow for the Passenger-Car Body Engineering Committee
Wayne Worthington for the Tractor Technical Committee
A. F. Meyer, Jr. for the Tube, Pipe, Hose, and Lubrication Fittings Committee

As New Chairmen of Technical Committees

W. C. Lawrence of the Aeronautics Committee
F. K. Glynn of the Commercial Vehicle

Continued on Page 95

. . . New Changes in SAE Standards

THE following have recently been approved by the SAE Technical Board:

CUT WIRE SHOT—A new SAE Recommended Practice for Cut Steel Wire Shot prepared by Division XX of the SAE Iron and Steel Technical Committee as a users' guide in selection and application.

CAST SHOT—Cancellation of the SAE Recommended Practice on Shot for Peening and notation that it is superceded by the SAE Recommended Practice on Cast Shot and Grit for Peening and Cleaning. This change was recommended by Division XX of the SAE Iron and Steel Technical Committee.

SHOT PEENING MANUAL—A new SAE Special Publication entitled "Manual on Shot Peening" prepared by Division XX of the SAE Iron and Steel Technical Committee as a practical aid to engineers, designers, and shop men.

LIGHTS—In the SAE Standard on Lighting Equipment for Motor Vehicles addition to the sentence "Any unit showing evidence [after vibration testing] of material physical weakness, lens or reflector rotation, displacement, or rupture of parts shall be considered to have failed" of the clause "provided that rotation of lens or reflector shall not be considered as a failure where tests show compliance with specifications despite such rotation." This was proposed by the SAE Lighting Committee.

FUEL AND OIL HOSES—In the SAE Recommended Practice on Fuel and Oil Hoses (SAE R 30), under Synthetic-Rubber, Wire-Reinforced, Circular-Woven Type with Lacquer Cover, addition of definitions of the wire-reinforced and nonmetallic types of hose construction. The change was recommended by the Nonmetallic Materials Committee.

RUBBER COMPOUNDS—Addition to the SAE Standard on Classifications and Physical Requirements for Rubber Compounds (SAE R 10) of a new "TA" category of temperature-resistant compounds, a key to the designation system, and a glossary. These additions were proposed by the SAE Nonmetallic Materials Committee.

COOLANT HOSES—Revisions of the SAE Standard on Coolant-System Hoses (SAE R 20) to bring it into conformity with the simultaneously revised designation system (SAE R 10). The revisions had been approved by the SAE Nonmetallic Materials Committee.

SPONGE AND FOAM RUBBERS—New SAE Recommended Practices for Sponge and Expanded Cellular Rubber Products and for Latex Foam Rubbers recommended by the SAE Nonmetallic Materials Committee.

GASKETS—A new SAE Recommended Practice for Nonmetallic Gaskets for General Automotive and Aeronautical Purposes setting forth an identification numbering system and test procedures. This has been prepared by the SAE-ASTM Technical Committee on Automotive Rubber and approved by the SAE Nonmetallic Materials Committee.

HYDRAULIC CUPS—New SAE Standards for Rubber Cups for Hydraulic Actuating Cylinders for Passenger Cars and Other Moderate-Duty Vehicles and for Heavy-Duty Vehicles. These standards describe performance tests but do not specify chemical composition, tensile strength, or elongation of the rubber compounds. The standards were drawn up by the SAE-ASTM Technical Committee on Automotive Rubber and approved by the SAE Nonmetallic Materials Committee.

CASTINGS-REPAIR MANUAL—A new SAE Special Publication on repair of defects in new castings. This manual prepared by a division of the SAE Iron and Steel Technical Committee is intended to replace the castings-repair section of SP-20 "Foundry Process Control Procedures."

CALENDAR

Atlanta—March 17

Gridiron, dinner 7:00 p.m.; meeting 8:15 p.m. The New De Soto V-8 Engine—Bernard Meldrum, chief engineer, De Soto Division, Chrysler Corp. Cocktails sponsored by Wagstaff Motor Co.

Buffalo—April 17

Hotel Sheraton, dinner 7:00 p.m.; meeting 8:00 p.m. Latest Developments in Induction Heating—H. B. Osborn, Jr.

Canadian—April 25

Prince Edward Hotel, dinner 6:30 p.m.; meeting 8:00 p.m. Speaker from Chrysler Corp.

Central Illinois—April 9-10 and April 23

April 9-10—1952 SAE Earthmoving Industry Conference.

April 23—Hotel Jefferson, dinner 6:30 p.m.; meeting 7:45 p.m. Hot Rod meeting—Wally Parks and Don Francisco, editors, Hot Rod Magazine, Los Angeles. Color film of Hot Rod tests and slides of engine parts will be shown.

Chicago—April 8

Knickerbocker Hotel, dinner 6:45 p.m.; meeting 8:00 p.m. Evolution of Motor Truck Design—J. N. Bauman, White Motor Co. Social half hour—6:15 to 6:45—sponsors to be announced.

Cleveland—April 14

Chesterfield Inn, dinner 6:30 p.m.; meeting 7:30 p.m. Buick XP-300 Car, Charles Chayne, vice-president, General Motors Corp.

Colorado—April 23

Wolhurst Country Club, dinner 7:00 p.m. Ladies Night meeting, dinner, social hour, and entertainment.

Dayton—April 8 and April 25

April 8—Inspection Trip, Columbus, Ohio.

April 25—Van Cleve Hotel, dinner 7:00 p.m.; meeting 8:00 p.m. Hot Rod Design, Maintenance and Operation. Hot Rod Association of America.

Detroit—April 7, 15, and 21

April 7—4:00 p.m.—Tour of Doehler-Jarvis Die Casting Plant, Toledo, Ohio
6:00 p.m.—Reception, Commodore Perry Hotel, Toledo, Ohio
6:30 p.m.—Dinner, Commodore Perry Hotel

An Engineer Looks at Atomic Energy—George G. Brown, Dean of Engineering, University of Michigan. Toastmaster: Royce G. Martin, president, Electric Auto-Lite Co. Dinner—$5.00 per plate.

April 15—Junior Group Field Trip—Tour of Packard Motor Car Co. Proving Grounds, Utica, Mich. Time: 2:00 p.m.

April 21—Rackham Educational Memorial Bldg., dinner 6:30 p.m.; technical session 8:00 p.m. Problems and Trends in Engineering Education—Dr. Frederick L. Hovde, president, Purdue University. Model Airplane Engine Contest entries by Student Branches. Dinner: Student Members—$1.50 per plate; Members $2.50 per plate.

Indiana—April 24

Marott Hotel, Social hour 6:30 p.m.; dinner 7:00 p.m.; meeting 8:00 p.m. Hot Rod Meeting—Wally Parks, editor, Hot Rod Magazine. Don Francisco, editor, Hot Rod Magazine. Color film slides.

Milwaukee—May 2

Racine, Wis.; dinner 7:00 p.m.; meeting 8:00 p.m. Better Engine Air Cleaning and Its Effect on Engine Wear and Performance—Einar Dahl, Massey-Harris Co. Plant trip through Massey-Harris Co. in afternoon.

Mohawk-Hudson—April 25

Circle Inn, dinner 6:30 p.m.; meeting 8:00 p.m. Mechanical Octanes—Alex Taub, president, Taub Engrg. Co. Guest speaker: SAE President D. P. Barnard.

Montreal—April 21

Mount Royal Hotel, dinner 7:00 p.m.; meeting, 8:00 p.m. Recent Developments in Aluminum in the Automotive and Aircraft Industry, Gordon R. Black, manager, Sales Development Division, Aluminum Co. of Canada. Black will also show film entitled "Curiosity Shop."

Northern California—April 23

Engineers Club, dinner 6:30 p.m.; meeting 7:30 p.m. Diesel meeting. Speaker to be announced. Warren Brown, chairman.

Philadelphia—April 9 and May 2

April 9—Engineers Club, dinner 6:30 p.m.; meeting 7:45 p.m. Vehicle Conservation on a Defense Economy—William D. Pidd, Chevrolet Motor Division, GMC.

May 2—Ladies night at Bala Country Club at 6:15 p.m.

Pittsburgh—April 22

Mellon Institute, dinner 6:30 p.m.; meeting 8:00 p.m. New Applications and Developments in Aluminum Alloys—J. H. Dunn and E. P. White, Aluminum Co. of America.

St. Louis—April 8

Gatesworth Hotel, dinner 7:00 p.m.; meeting 7:45 p.m. New Ideas in Carburetion—J. T. W. Moseley, chief engineer, Carter Carbureter Corp.

Twin City—April 9

Curtis Hotel, dinner 6:30 p.m.; meeting 8:00 p.m. Recent Developments in Power Steering—Ralph M. Lehman,

NATIONAL MEETINGS

Meeting	Date	Hotel
AERONAUTIC, AIRCRAFT ENGINEERING DISPLAY, and TECHNICAL AIR REVIEW	April 21-24	Statler, New York City
SUMMER	June 1-6	Ambassador and Ritz-Carlton, Atlantic City, N. J.
WEST COAST	Aug. 11-13	Fairmont, San Francisco
CENTENNIAL of ENGINEERING BANQUET	Sept. 4	Hotel Knickerbocker, Chicago
TRACTOR and PRODUCTION FORUM	Sept. 8-11	Schroeder, Milwaukee
AERONAUTIC, AIRCRAFT ENGINEERING DISPLAY, and PRODUCTION FORUM	Oct. 1-4	Statler, Los Angeles
TRANSPORTATION	Oct. 22-24	William Penn, Pittsburgh
DIESEL ENGINE	Oct. 30-31	Chase, St. Louis, Mo.
FUELS AND LUBRICANTS	Nov. 6-7	The Mayo, Tulsa

field engineer, Ross Gear & Tool Co.

Washington—April 15

Burlington Hotel, dinner 7:00 p.m. Passenger Service Scheduling and Reservation Problems and English Jet Transport Development—Allen W. Dallas.

Western Michigan—April 29

Stern's Steak House, dinner 6:30 p.m.; meeting 7:45 p.m. The Growth of Hot Rods in the Southwest—Wally Parks and Don Francisco, editors, Hot Rod Magazine.

Williamsport—April 7

Williamsport Airport Restaurant, dinner, 6:15 p.m.; meeting 8:00 p.m. Recent Developments in Aluminum—E. J. Willis, development engineer, Aluminum Co. of America.

25 Years Ago

Facts and Opinions from SAE Journal of April, 1927

Polled to determine what subjects are of particular interest today, a list of representative members chose four-speed transmissions as the subject of most general interest. Other subjects ranking high on the list included brakes, headlighting, riding qualities, the car of 1937, superchargers, high-speed versus low-speed engines, lubricants, fuels, shock-absorbers, and shimmy.

■

The proposed Indianapolis race for cars driven by oil engines has been abandoned for this year. It is felt that sufficient time is not available (1) to formulate rules that would be fair and practical, and (2) for engineers to design, and factories to build, cars to compete in it.

■

The demand for lower cars has brought the rear-seat cushion down until it is between the wheels where the width of the cushion is fixed absolutely by the tread of the car and the tire diameter. In cars with fairly large tires, it is not possible to place a cushion more than 44 in. wide at that point, although we still optimistically call it a three-passenger seat.—H. M. Crane of General Motors in discussing Annual Meeting Paper by Alan R. Fenn.

■

"The average truck in the United States runs only an average of 26.3 miles per day," noted A. W. S. Herrington at a meeting of the Metropolitan Section.

■

The lighter-weight high-speed diesel engine is rapidly becoming a reality. Progress made in experimental laboratories in the last year or two indicates that higher speeds are not impossible nor improbable.—W. W. Schettler, Foos Gas Engine Co. at Indiana Section Meeting.

■

There is not much indication that motorcoaches will ever be on a par with street-car transportation in large cities, pointed out R. N. Graham of the Pennsylvania & Ohio Railways in a Metropolitan Section paper.

■

One of the engineering developments of the next decade undoubtedly will be wide application of diesel engines to land transportation. Small likelihood exists for this type of engine being used in passenger cars but for railcars, which may burn as much as $50 worth of gasoline per day, it may convert an unprofitable service into a profitable one.—P. M. Heldt of Automotive Industries in Indiana Section Meeting Paper.

■

"Advantages of lightweight aluminum pistons are so great," C. D. Welty of the Aluminum Company of America told a Buffalo Section Group, "that some of the builders of four-cylinder cars almost owe their success to the performance they have been able to obtain by using them."

■

Chromium-plating for decorative effect has been used for considerably more than a year on the Oldsmobile radiators and bumper-bars and is now being extended to other cars built by General Motors.—W. N. Phillips, General Motors, in Annual Meeting Paper.

Continued from Page 93

Nomenclature Committee

A. F. Meyer, Jr., of the Construction and Industrial Machinery Technical Committee

W. J. McCortney of the Nonmetallic Materials Committee

B. R. Weber of the Trailer Hitch Committee

G. A. Rae of the Tube, Pipe, Hose, and Lubrication Fittings Committee

As SAE Representatives on ASA Sectional Committees

George McCain and Paul Richards on ASA Sectional Committee Y32 on Graphical Symbols

Charles Wright on ASA Sectional Committees B1 on Standardization and Unification of Screw Threads; B2 on Pipe Thread; B18 on Bolts, Nuts, Rivets, Screws and Similar Fasteners; and B27 on Standardization of Washers and Machine Rings

Fred Lautzenhiser on ASA Sectional Committee B13 on Logging and Sawmill Safety

As SAE Representatives to Other Organizations

Roy Roush and M. L. Frey to the Joint Committee on Definition of Heat Treating Terms

V. J. Roper as alternate to B. B. Bachman on the Highway Research Board

Group Starts Work on Turning Radius Criteria

A RECOMMENDED practice for predicting and measuring truck turning ability is in the making. A task group of the SAE Load and Dimension Limitations Subcommittee decided recently to develop more accurate formulas and test procedures for determining:

1. Turning ability from a known truck configuration.
2. Truck configuration required to obtain a desired turning ability.
3. Actual turning ability of trucks.

It is felt that the recommended practice should contain criteria and definitions for expressing such turning ability in terms of turning radius, vehicle clearance circle, and curb clearance circle (the smallest circle within which a vehicle can clear a curb 6 in. high).

Preliminary formulas and procedures prepared by the task group are now being used as a basis for further work.

Serving on this Turning Radius Group are M. C. Horine, Mack; F. B. Lautzenhiser, International Harvester; and C. C. Saal, Bureau of Public Roads.

SAE Section Meetings

Outlines Rules For Engine Bearing Installation

• Salt Lake Group

J. P. Bywater, Field Editor

Feb. 21—Proper methods of maintenance and installation of engine bearings were described in detail by **Walter E. Thill**, assistant chief engineer, Federal-Mogul Corp. One approach to the problem of the proper installation of engine bearings, he said, is to consider the following points individually:

1. Is the housing (connecting rod or main bearing saddle) into which the bearing is being assembled round, reasonably smooth, straight, and of proper size?

2. Does the new insert bearing meet the physical requirements; that is, similar grooving and oil holes, proper materials, and correct undersize for the replacement?

3. Is the shaft round, smooth, and straight, and of the correct size?

4. Is the oil clearance correct?

5. Will good clean oil be supplied to the bearings under pressure?

These are the major points for consideration in dealing with a given engine bearing. Deviations from practical limits on any of these can lead to trouble, in the form of shortened bearing life or possible immediate failure, depending upon the degree of the deviation.

Oil is a necessary evil, Thill said: it is necessary for lubrication, and engine bearings cannot function without it; but it is also an excellent carrier of dirt—dirt in the form of cast iron, hard carbon, corundum, or steel.

When these particles are carried into the bearings, particularly in quantity, trouble ensues in short mileage. Smaller quantities of dirt cause other troubles, such as excessive shaft wear, resulting in unsatisfactory performance. Seventy-five per cent of bearing troubles can be attributed to dirt, Thill said.

All bearing materials represent a compromise, in that it is impossible to have a material soft enough to absorb large quantities of dirt and still capable of withstanding heavy loads.

With an engine that is built right, there are still two more factors that can affect the life of the engine. One is the break-in; the second has to do with the driver and his habits. The elements of handling the vehicle that affect bearing wear include engine care, lugging, overspeeding, and the like. Good engine care is necessary for optimum overall results from a good repair job.

Thill concluded that engine bearings can and do last a long time if the job is done right.

Salt Lake Group Chairman Stanley W. Stephens presided at the meeting.

At the Feb. 21 meeting of Salt Lake Group, Walter E. Thill of Federal-Mogul Corp. explained bearing inserts. Left to right: Dean Despain, vice-chairman of the Group; J. P. Bywater, field editor; Walter E. Thill; L. J. Giacomozzi of Federal-Mogul Corp., and Richard Ostlund, secretary-treasurer of Salt Lake Group

Hawaii Section Hears Hints on Diesel Maintenance

• Hawaii Section

The January meeting of Hawaii Section took 140 members to the shops of Kawaiahao, Ltd., to view repair and test equipment particularly adapted to the maintenance and repair of heavy duty construction equipment and diesel engines.

C. S. McKinley, vice-president and designing engineer of Automotive Products, Inc., Portland, Ore., gave a short talk on several phases of diesel care, operation, and application, and then very ably demonstrated the application of the diesel fuel-injection testing and servicing equipment manufactured by his firm and installed at Kawaiahao.

Cleanliness is the first and most important item in the handling of fuel and lube oil for diesels, McKinley said. Whenever possible, the vehicle should be taken to the fuel supply rather than the reverse, since one of the most effective ways to clean fuel is to permit settlement of impurities. The dispenser pump intake should be at least five or six inches above the bottom of the storage tank. Good quality filters and elements should be used and elements replaced in preference to attempting to clean them. A sock type element which has been cleaned too many times is not an effective filter. Paper filters are preferable for final stage filtration.

Regardless of manufacturers' recommendations in regard to timing injection by the marks, some increase in output often may be realized by ad-

vancing injection when the type of pump permits, McKinley said. The manufacturer cannot guess the quality of the fuel each operator will use, and so provides a reasonably good setting for a wide range of fuel qualities. In general, asphaltic base fuels require greater advance than the paraffinic. Timing should be advanced if exhaust smoke is light blue; retarded if smoke is white. Black smoke is unburned fuel and indicates too much fuel. The ideal indication is light grey smoke with traces of black.

Not only should the diesel engine be timed to the fuel, but the calibration of the fuel pump on the test stand should be determined by the quality of the fuel. No rules can be given for determining correct calibration. Cut-and-try methods based on observation and experience during actual engine operation will determine correct settings. If fuel quality is poor and maximum performance not obtainable by advancing injection, greater fuel delivery may be the answer.

Standard replacement parts only should be used when repairing engines, and engines should only be used in the way the manufacturer intended. Engines should not be overworked.

A simple stunt for conserving cleaning solvents was hit upon accidentally by McKinley. Simply mix the solvent with water. The solvent will rise to the top of the water. Impurities settling out of it will be permanently retained by the water. A piece of one-eighth or quarter-inch, coarse wire mesh placed about an inch above the top of the water in the container will keep the water from being agitated while washing articles in the solvent. Some rust inhibitor added to the water will prevent rusting of metal containers.

Theater Party Marks Ladies' Night

• St. Louis Section

W. H. Cowdery, Field Editor

Jan. 28—The January meeting of St. Louis Section was devoted to the ladies. After cocktails and dinner, 195 members and guests attended a theater party at the St. Louis Community Playhouse. The play, Emlyn Williams' "Night Must Fall," provided the playgoers with a thrilling evening. Between acts coffee was served, and after the final curtain the party adjourned to "The Crypt" in the basement of the Playhouse for beer, cokes, pretzels and popcorn. A phonograph provided dance music.

Everyone enjoyed an entertaining evening, and is looking forward to next year's social meeting.

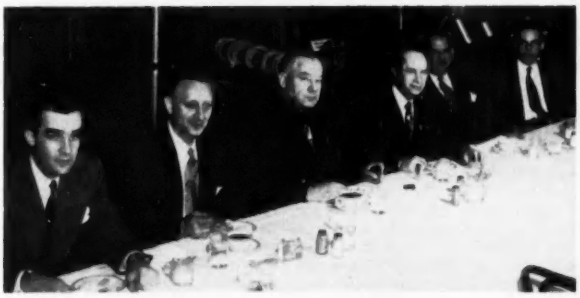
Indiana Section Guest At a Factory Open House

• Indiana Section

Feb. 14—Schwitzer-Cummins Co. of Indianapolis played host to the Indiana Section at one of the group's most successful meetings in years. Many Section members spent part of the day seeing how Schwitzer-Cummins fabricates automotive subassemblies and ventilating equipment. After dinner, the group heard company engineers describe their products—such as axial flow and sirocco type fans, gear and vane type oil pumps, centrifugal water pumps, torsional vibration dampers, and superchargers.

Indianans Learn About Schwitzer-Cummins' Products . . .

And Sup with Company Engineers . . .



And Head Men of Section and Company. (left to right) H. H. Schuldt, assistant chief engineer of Schwitzer-Cummins; Kurt Beier, chief engineer of Schwitzer-Cummins; Section Vice-Chairman R. P. Atkinson, Allison Division, GMC; last year's Section Chairman S. A. Silbermann, Metallurgical Service Co., and Section Secretary D. S. Bowman, Columbia Transportation Service, Inc.

Barnard and Sikorsky Speak at Cleveland Section

1. On arriving at Cleveland Airport for the Feb. 11 meeting of Cleveland Section, SAE President Daniel P. Barnard, whose hobby is old cars, was met with a 1913 White touring car

2. At the NACA Laboratory Barnard cranks the White before taking other meeting guests for a ride. Left to right: Dr. Barnard; Igor I. Sikorsky, who was main speaker at the meeting; Cleveland Section Chairman R. I. Potter; R. C. Sackett, SAE Detroit staff representative; Edward R. Sharp, director of the NACA Lewis Flight Propulsion Laboratory; and E. E. Bisson of NACA

3. At the evening meeting, Cleveland Section Chairman Raymond I. Potter described Barnard as the "king-size man" needed for the post of SAE president and presided over the coronation. Potter first annointed Barnard wih SAE oil

4. With a blare of trumpets, President Barnard was crowned king of SAE. Approximately 500 attended the meeting that followed a buffet supper in the NACA cafeteria

• Cleveland Section

W. B. Fiske, Field Editor

Feb. 11—A bang-up meeting featuring **Igor I. Sikorsky** as speaker and **President Daniel P. Barnard** as coffee speaker brought out a crowd of approximately 500, with 400 attending the buffet dinner in the cafeteria of the National Advisory Committee for Aeronautics.

The surprises of the day began for President Barnard when he was met at the Cleveland Airport with a 1913 White touring car borrowed from the Thompson Auto Album collection. Dr. Barnard drove the car two miles to the beautiful headquarters of the NACA, where the meeting was held, and was greeted by Igor Sikorsky and Dr. Edward R. Sharp, director of the NACA Lewis Flight Propulsion Laboratory, who was speaker's sponsor at the meeting.

Following the buffet, Dr. Barnard spoke on cooperative research, pointing out that the tides of progress have been furthered by the curiosity of engineers and a will to improve things, and that this constructive force has an even greater importance today.

Barnard pointed to the great shortage of technical manpower at present, due partly to the comparatively small enrolment in our technical schools and colleges as a result of military training. Far more engineers are needed than are being turned out, and he voiced the hope that trained technical men might be excused from guarding bridges and docks when their skill and knowledge would make them far more useful in their professional fields.

Speaking on the subject of "Helicopters in War and Peace," Igor I. Sikorsky, engineering manager of Sikorsky Aircraft Division, United Aircraft Corp., discussed experiences in developing early helicopters and other aircraft and the trend of thinking in earlier days. He pointed out that helicopters would never be designed to compete with airplanes in speed, but that their chief usefulness lies in the fact that they can land and take off anywhere, in contrast to large aircraft which require great fields and up to two miles of runway.

The best example of how useful helicopters can be is found in the rescue work and the supplying of armed forces in the wild, impenetrable mountains of Korea. Here they have been able to let down men with a rope and have a landing place cleared in a matter of minutes. Outstanding records have been made in rescuing men cut off from base and in moving out the wounded. As a result the helicopter in Korea has aptly been called "The Guardian Angel." A movie by that title was shown by Sikorsky after his talk, showing amazing feats of this aircraft in Korea.

Sikorsky said that up to the present the greatest sustained flight of a heli-

copter has been 700 miles, and the top speed has been 129½ mph. He thought that 150 mph could be readily attained, and that 175 mph might be reached. However, he predicted that the helicopter will never be designed to compete with other aircraft in speed.

Sikorsky described the three basic types of helicopters: the single rotor types in common use today, the compound type of ship with plane wings added to carry a part of the weight when under way, and the convertible type which might be changed to a plane in the air.

Looking to the future, Sikorsky offered his personal opinion that the rotor types will be most useful. He predicted larger rotors and more horsepower. The disc loading factor (area of the rotating blade) is most important in helicopters, he said. We now get 2 to 3½ pounds of carrying power per square foot. While we are carrying from 11 to 12 pounds per horsepower of carrying power in modern helicopters, this should be limited to 10 or even 8 pounds for best results. As far as durability is concerned, he pointed out that some of our present helicopters have had 5000 hours in the air with only moderate repair and maintenance. As a type of ship that needs no permission or special facilities to go up, the helicopter promises much for the future.

Another surprise for Dr. Barnard was the coronation of the new SAE president. Cleveland Section Chairman Raymond I. Potter told the audience that it takes a king-size man to hold down such an important office, and at a cue from him a quartet of helpers came down the aisle bearing a full-size throne. To this throne Dr. Barnard was escorted, and, with all due ceremony and the annointing of his head with SAE oil, was fittingly crowned king of SAE.

Still another attraction of the Cleveland Section meeting was an aeronautical display in the NACA hangar featuring the Royal Canadian Air Force experimental and proving plane devoted to the study of icing problems. The ship, called the "Rockliffe Ice Wagon," was inspected and its features and instruments explained.

Describes Types Of Anti-Friction Bearings

• Cincinnati Section

Walter Walkenhorst, Jr., Field Editor

Jan. 28—The vital importance of anti-friction bearings in the automotive industry was emphasized by **Robert Riblet**, chief engineer of the Timken Bearing Co., before 160 members and guests of the Cincinnati Section.

Riblet used slides to illustrate the various types of anti-friction bearings used in the automotive field. The question period that followed the talk was used to full advantage by the large gathering.

After the appointment of the committee to nominate the Section officers for the coming year, the group continued their discussion during a refreshment period.

Barnard Stresses Need for Engineers

• Philadelphia Section

R. W. Benson, Field Editor

Feb. 13—**Dr. D. P. Barnard**, 1952 SAE President, spoke on "Research—a Partner in Engineering" at a meeting attended by more than 150 members and guests. Linn Edsall, Philadelphia Section Chairman, introduced the speaker.

Dr. Barnard divided his subject into three parts, (1) Curiosity, (2) Crude Oil and (3) Education. The curiosity of pre-historic man gave us wheels, starting us along the path toward modern vehicular transportation. He described the increase in the yield of gasoline from crude oil, starting with the earliest straight run and thermal cracking processes through the introduction of tetraethyl lead to the present catalytic cracking and reforming processes. He illustrated the octane number increases made possible by improvements in the cracking processes and discussed the molecular structure of gasoline.

The need for larger numbers of graduate engineers and the possibility that there would be an insufficient number of engineering students graduating in the next several years was emphasized. Dr. Barnard stated that an aggressive body of engineers in industry is very necessary to the continued progress of our country.

"Hard Times" Costumes Feature of Ladies' Night

• Western Michigan Section

Tom Reeves, Field Editor

Nov. 20—The annual Ladies' Night of Western Michigan Section brought out "glad rags" that really were rags. The party featured "hard times" costumes, with prizes for the most disreputable. A one dollar fine was levied against those judged too well dressed for the occasion.

The family style dinner at Bill Stern's Steak House was followed by music and singing, a chalk talk, a full-fledged quiz program, and dancing by Miss Greater Muskegon.

You'll Be Interested to Know . . . .

AN ARTICLE D. B. BROOKS AND S. W. SPARROW wrote 25 years ago is still being referred to for information on "Oil-Flow through Crankshaft and Connecting-Rod Bearings." We know because H. R. Charge of Marchworth, Furzefield Road, Reigate, Surrey, England wrote us on January 3 to point out that the equation

$$AP \sec \theta = [W/g] [(2\pi N^2/60)] [(L+1)/2]$$

should read

$$AP \sec \theta = [W/g] [(2\pi N/60)^2] [(L+1)/2]$$

This is Equation 2 on page 131 of the August 1927 Journal. The velocity-squared term should, of course, read similarly in Equation 4 on that page also.

ASKED TO COMMENT ON THE ABOVE, CO-AUTHOR S. W. SPARROW RESPONDS:

"During the past 30 years your esteemed publication has printed a considerable number of articles for which I have been wholly or partly responsible. . . . I have long cherished the hope that someday someone would read one of the things—and your evidence that this has finally happened gives me deep and abiding satisfaction." (Editors note: On pages 17-20 of the March issue of the Journal appeared Past-President Sparrow's latest contribution to "this esteemed publication.")

SAE Student News

San Diego State College

Last semester's program included field trips, papers by eminent speakers, and movies. John F. Lyons, fuels and lubricants engineer for the Texas Co., spoke on recently-developed applications of atomic energy in research on fuels and lubricants and showed the film "Thanks to the Atom."

Dr. John V. Long, director of research at Solar Aircraft Corp., gave an interesting talk on "Ceramic Coatings," at the November meeting, and October's activities included a field trip to the Naval Electronics Laboratory in San Diego.

—Leon G. Hidde

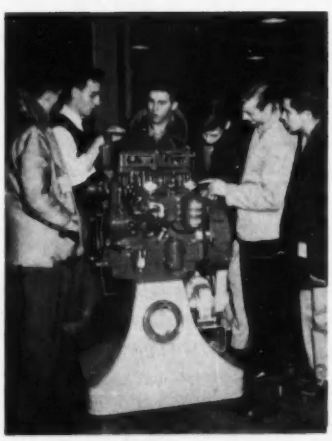
Cal-Aero Technical Institute

On Jan. 16, a field trip to the El Segundo refinery of Standard Oil Co. of California brought out more than 95% of SAE Student Branch members at Cal-Aero. The tour was arranged by outgoing officers C. H. Stauffer, Robert Towers, and J. G. Ruede.

The trip began at 10:15 A.M., with all transportation provided by Standard Oil Co. On arriving at El Segundo, the students were treated to a delicious meal at the company's modern cafeteria, followed by a two-hour tour of the oil field. John L. Dickinson, chief engineer of Cal-Aero, Abe Victor, the Branch's faculty adviser, and Arthur Speer and Frank Gadomski of the faculty accompanied the students.

New Student Branch officers Robert Benkert, chairman, Ray Crabtree, vice-chairman, and William Wang, secretary-treasurer, were installed when the group returned from the tour.

—William Wang



Examining a Continental diesel engine are some of the student guests from the Muskegon Community College who toured the laboratory and engineering departments of Continental Motors Corp. The January tour was sponsored by the student activities committee of Western Michigan Section, headed by Philip Webster of Continental

Wayne University

Activities of the Student Branch at Wayne University are now back in full swing after being somewhat curtailed during the Christmas holidays and final examinations. Officers for the new semester have been chosen, with Anthony Machis elected chairman, James Baker vice-chairman, Chester Selden secretary, and Richard Richards treasurer.

At the Jan. 4 meeting Robert Weiss, methods superintendent of Ternstedt Division of General Motors Corp., spoke on "The Function of Methods Engineering in Mass Production." In addition to his post at Ternstedt Division, Weiss is a part-time instructor in the Industrial Engineering Department at Wayne.

Progress has been made on the experimental engine contest coming up at the Detroit Section banquet. Richard Richards is in charge of Wayne's entries, and the Student Branch expects to give the other participants some real competition.

The job placement service has been busy with recent mid-year graduates. There are now more jobs than applicants, so the problem is mainly one of picking and choosing.

A new membership drive is being launched to strengthen SAE Branch ranks following the graduation of all of last semester's officers and several other members. The drive was kicked off at the annual banquet on March 4, at which Dean Carr of the College of Engineering and William J. David, the Branch's faculty adviser, gave brief talks. Entertainment was provided by Hy Pritz of Station WXYZ, Detroit.

With a full program of activities for the spring semester under way, the Student Branch at Wayne is not awaiting future developments, but is setting out to develop the future.

—James L. Gullberg

University of Colorado

Activities of the SAE Student Branch at the University of Colorado for the school year opened with a talk by Hollister Moore of the SAE, who described the correlation of the various engineering societies and spoke on how to get the most out of SAE. On Oct. 24, Charles L. Carpenter of Coors Porcelain Co. described the uses, methods and costs of using porcelain in the automotive industry. More recently, J. T. Bugbee of the Texas Co. presented his paper "Talented Transmissions."

On Feb. 26 Floyd Sparkman, Sparkman-Barber Co., gave an illustrated presentation of the paper "The Humphreys Constant-Compression Engine," by W. H. Paul and I. B. Humphreys. Humphreys brought his Oldsmobile, equipped with the constant-compression engine, for inspection and demonstration.

The meeting was attended by 125 students, faculty members and off-campus guests. Before the meeting student officers of the Branch enjoyed dinner with Humphreys and Sparkman, several members of the engineering faculty, and Marcellus Merrill of Colorado Group, who entertained the students with reminiscences of early-day automobiles and races.

A dinner meeting was planned for early March, at which the Student Branch would play host to Colorado Group. Three student papers were scheduled for presentation.

—Robert E. Berry

General Motors Institute

At the December meeting of the SAE Student Branch at General Motors Institute Charles A. Chayne, vice-president in charge of engineering of General Motors Corp., presented a talk on the designing features of the Buick

Wilmot Sandham of General Petroleum Corp. describes the procedure and results of the Grand Canyon Economy Runs to the SAE Branch at the University of Colorado on Jan. 18. Sandham (left) receives the thanks of Frank Berto, chairman of the Student Branch

XP 300 experimental car. An XP 300 was on display.

An Australia Holden car was inspected at the January meeting, and its design was described by a member of General Motors Overseas Operations.

Parks College of Aeronautical Technology

Seventy-five members and guests attended the annual banquet of the SAE Student Branch at Parks College which was held Feb. 5. A steak dinner preceded the meeting, which was opened by William Carrozza, Student Branch chairman. Carrozza reviewed the history and achievements of the Branch during the past year, pointing out that membership had increased from 97 to 125 students. He expressed his desire to increase both membership and activities during the new year.

E. S. Rehagen, central station supervisor of Westinghouse Electric Corp., St. Louis, Mo., then spoke on "Things to Consider in the Application and Maintenance of Turbojet Engines." Rehagen emphasized, among other things, the need for a faster system of ground handling of jet aircraft and better technique of maintenance.

Following Rehagen's presentation, J. W. Lawton, district supervisor, aviation gas turbine service, Westinghouse Electric Corp., answered questions on the J-34 axial flow turbojet engine, using a large cutaway photograph of the turbojet for reference.

E. S. Rehegan of Westinghouse Electric Corp. was main speaker at the annual banquet of the SAE Student Branch at Parks College on Feb. 5. At the speaker's table, from left to right, are: Father Murller, professor of philosophy; J. W. Lawton of Westinghouse Electric Corp.; James Gilchrist, Student Branch treasurer; E. S. Rehegan; William Carrozza, chairman of the Branch; John R. Mylin, faculty adviser; Edward Barker, assistant dean and registrar; and Father Higgins, student counselor of Parks College

New officers of the SAE Student Branch at Northrop Aeronautical Institute are, left to right: John Dunstan, chairman; Myron S. Jackson, vice-chairman; Faculty Adviser K. L. Strite; Jerry C. Russell, secretary; and Sidney E. Gilbert, treasurer

University of British Columbia

The third week of January was a busy one for the U.B.C. Student Branch. On Jan. 15, **J. T. Bugbee** of the Texas Co. gave a very pertinent talk, illustrated with slides, on "Talented Transmissions." On Jan. 18, **Wilmot Sandham** of General Petroleum gave a highly enlightening address on the "Grand Canyon Economy Run." Both speakers attracted audiences of well over 100 and discussion continued among the student members for some time after the talks.

Bugbee outlined the history of the torque converter, beginning with the lever and fulcrum, and went on to define the difference between a torque coupling and a torque converter as consisting of the "fulcrum" or reactor blading present in the converter but not in the coupling. He then described the essential features and differences of the standard automatic transmissions in use today. A lively discussion followed the meeting.

Sandham described the precautions taken by General Petroleum and the A.A.A. to ensure a fair running of the economy run, and explained that the mileages obtained in the run could be obtained in any car by careful driving. Using large models of a vacuum gage, exhaust gas analyzer and speedometer, Sandham explained the relationship of the three and showed in which region the highest economy could be obtained. For maximum mileage the power valve of the carburetor should never open. The most valuable aid to mileage economy is a vacuum gage, and an attempt should be made to keep the vacuum above 10 in. Hg.

A film of the Grand Canyon Economy Run was shown after the meeting and a considerable number of students missed their first afternoon lecture to question Sandham after the film.

—Frank Berto

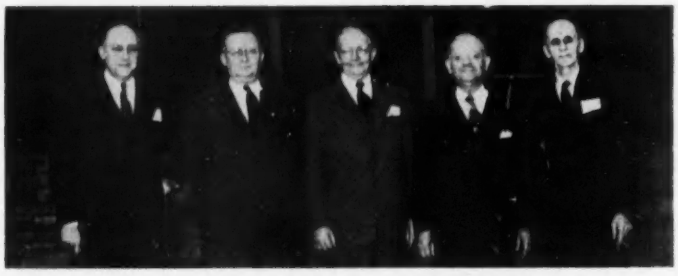
Case Institute of Technology

Final results of the election of new officers of the SAE Student Branch at Case have been announced.

Walter Wilgus, a junior from Cleveland in the Department of Mechanical Engineering, is chairman for the new semester. Richard J. Rozanc, vice-chairman, also from Cleveland, is studying engineering administration. Francis M. Baluck, a mechanical engineering junior from Youngstown, Ohio, is secretary-treasurer.

—Clifford C. Crabs

SAE President D. P. Barnard was guest of Philadelphia Section on Feb. 13. Left to right: John G. Moxey, Jr., of Sun Oil Co.; Dr. Barnard; Section Chairman Linn Edsall of Philadelphia Electric Co.; and Francis W. Kateley, vice-president of ACF-Brill Motors



On Feb. 25, 82 members and guests of Cincinnati Section toured the penicillin plant and the distilling plant of Schenley Distillers, Inc., in Lawrenceberg, Ind. Thatcher Glass Co., which produces bottles for Schenley, was also visited. Left to right: Howard A. Bischoff, meetings chairman of Cincinnati Section; E. P. Henderson, plant manager, Schenley Distillers; Section Chairman William A. Kimsey; R. H. Nanz, vice-president of Schenley Industries, Inc.; and A. G. W. Brown, Section publicity chairman

Blue jeans and patches were de rigeur at the Hard Times Party given by Western Michigan Section Nov. 20. Prizes were given to the worst dressers, and fines exacted from those not in costume

Sparrow Presents "My Friend, the Engine"

• St. Louis Section

W. H. Cowdery, Field Editor

Feb. 7—Past-President **Stanwood W. Sparrow**, vice-president of engineering of Studebaker, presented his famous paper on "My Friend, the Engine" before an overflow crowd at a joint meeting of St. Louis Section and the Engineers Club.

The paper which dealt with the development of the Studebaker **V-8** engine, was followed by an open discussion on a wide range of topics pertaining to engines, and many took advantage of the opportunity to put questions to Sparrow. It was brought out the economics of automobile production must take precedence over possible engineering improvements in many cases; increased costs may rule out even worthwhile developments.

After the meeting refreshments provided by the Engineers Club were served.

New Compositions Replace Strategic Materials for Jets

• Dayton Section

W. D. Hazlett, Field Editor

Feb. 19—**R. H. Thielemann,** development metallurgist for Pratt and Whitney Aircraft Division of United Aircraft Corp., presented the paper on "Trends in Gas Turbine Engine Materials" which he, J. C. Mertz, and W. P. Eddy, Jr., prepared for presentation at the SAE Annual Meeting in January.

The demand created by the defense program for more powerful jet engines in greater numbers, and the large amounts of critical alloying elements required for these engines, presents a challenge to engineering ingenuity, Thielemann said. But materials engineers are becoming better able to match properties of available materials with engine requirements as service experience with jets grows. In many cases, it has been possible to substitute less critical materials for highly alloyed compositions; in others, new, less critical compositions have been developed. Some of the new materials actually seem to have better properties than the ones they replace.

Methods of approach by which amounts of strategic materials can be reduced are: (1) by developing designs and manufacturing processes that utilize materials more efficiently; (2) by replacing stainless alloys with protectively-coated carbon or low-alloy steels; (3) by developing super-alloys

with lower strategic metal content. Problems encountered in each method of approach are numerous, but do not appear to be insoluble, Thielemann concluded.

Thomas O. Brightwell, assistant chief of the Dayton Fire Department, covered some of the technical points of firefighting in a coffee talk on "How You Can Help Your Fire Department."

Best Practices Are Needed for PM Programs

• New England Section

George T. Brown, Field Editor

March 4—Successful fleet operation in these times of increasing costs requires the best of modern maintenance practices, it was agreed by the panel of New England experts (all SAE members) which discussed bus and truck maintenance at tonight's meeting.

William Head, automotive superintendent, Public Service Co. of New Hampshire acted as moderator of the discussion, while the panel was assembled and introduced to the 92 members and guests by J. Henry Hickman, New England district engineer of GMC's Truck & Coach Division. Hickman's company also was host for the cocktail party which preceded the meeting.

Serving on the panel under Head's leadership were Gustav Heiber, vice-president of maintenance, Boston, Worcester and New York State Railway; Roy Smith, supervisor of automotive equipment, Metropolitan Transit Authority, Boston; and Louis Hankins, superintendent of maintenance, Interstate Trucking Co., New Bedford.

Head opened the discussion by defining the word "preventive" as applied to maintenance as "something that wards off." Drivers, he said, must take pride in the vehicles they operate—and they must make daily written reports to permit development of a suitable preventive program.

Roy Smith declared that the three basic needs for a good preventive program, are Engineering, Education and Enforcement—and in that order of importance.

Each garage or location has individual or unique characteristics as to the daily demands on equipment and men. With these demands known it is easier to determine best work procedures — also needed service equipment with location for easy accessibility.

Inspection schedules should be established, using the manufacturer's recommendations as a guide in writing a general inspection procedure. This should be made a part of standard practice at all locations.

There can be no hard and fast rule on unit changes laid down for all locations, he continued. Items particularly stressed for removal and over-

AMERICAN CHEMICAL PAINT COMPANY

AMBLER CHEMICALS ACP PROCESSES PENNA.

Technical Service Data Sheet

Subject: IMPROVING PAINT ADHESION ON STEEL WITH GRANODINE®

INTRODUCTION

"Granodine" is a zinc phosphate coating chemical which improves paint adhesion on steel, iron and zinc surfaces. In the Granodizing process, a non-metallic crystalline coating is formed on the treated metal. This bond holds and protects the paint finish and thus preserves the metal underneath.

Official Dept. of Defense Photograph

An F4U Corsair with the Navy's new aircraft anti-tank rocket, the "RAM". A Grade I zinc phosphate finish (JAN-C-490) protects the entire external surface of this rocket and provides a durable bond for the specification paint finish.

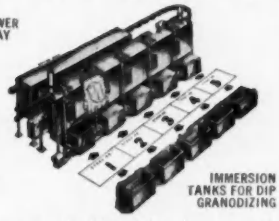
"GRANODINE" MEETS SERVICE SPECIFICATIONS

JAN-C-490, Grade I	CLEANING AND PREPARATION OF FERROUS METAL SURFACES FOR ORGANIC PROTECTIVE COATINGS
JAN-F-495	FINISHES FOR EQUIPMENT HARDWARE
U.S.A. 57-0-2C Type II, Class C	FINISHES, PROTECTIVE, FOR IRON AND STEEL PARTS
U.S.A. 51-70-1, Finish 22.02, Class C	PAINTING AND FINISHING OF FIRE CONTROL INSTRUMENTS; GENERAL SPECIFICATION FOR
MIL-V-3329	VEHICLES, COMBAT, SELF-PROPELLED AND TOWED; GENERAL REQUIREMENTS FOR

GRANODIZING DATA

Granodizing is an easily applied chemical process. Depending on the size, nature and volume of production, Granodizing can be carried out by spraying the parts in successive stages of a power washing machine, by dipping the work in the cleaning, rinsing and coating baths contained in tanks, or by brushing or flow coating the work with portable hand equipment. Typical process sequence and equipment requirements are shown below:

MULTI-STAGE POWER WASHER FOR SPRAY GRANODIZING



PROCESS SEQUENCE
1. Clean
2. Rinse
3. "Granodine"
4. Rinse
5. Final Rinse

IMMERSION TANKS FOR DIP GRANODIZING

NOTE: Equipment can be of mild steel throughout, except in the Granodizing stage, where nozzles, risers, and pump impeller should be of acid-resistant material.

MANY APPLICATIONS

Automobile bodies and sheet metal parts, refrigerators, washing machines, cabinets, etc.; projectiles, rockets, bombs, tanks, trucks, jeeps, containers for small arms, cartridge tanks, 5-gallon gasoline containers, vehicular sheet metal, steel drums and, in general, products constructed of cold-rolled steel in large and continuous production are typical of the many products whose paint finish is protected by "Granodine".

CHEMICALS ACP PROCESSES

WRITE FOR FURTHER INFORMATION ON "GRANODINE" AND YOUR OWN METAL PROTECTION PROBLEMS.

CHEMICALS ACP PROCESSES

haul at one location may be at 30,000 miles, while the same unit at another location may be good for 50,000 miles.

In addition to the regular inspection procedure, certain methods and test procedures on particularly troublesome individual units must be clarified. Then, in an emergency, they can be followed by men not familiar with that particular part in their regular work assignments.

Education starts with the foreman, Smith said. They are the men who must be "sold" on a preventive program to insure its success. And their natural instincts or curiosities cannot be relied on. The belief that "good mechanics are born and not made" may have some basis, but real efficiency is best served by proper training and exact knowledge.

Gus Heiber depicted another phase in efficient maintenance when he declared that it is unsound to set up a unit replacement program based only on the assumption that it would be a nearly positive protection against possible road failures.

Good service equipment he stressed, is essential to minimize the time element in taking care of road failures or pull-ins. Mechanics trained in the special art of making quick permanent repairs should be available to restore the vehicle to its proper condition or get it into a repair shop.

Proper logging of road failures reports can be a valuable help in reducing the number of road failures, he concluded. Pull-in repairs are one means of checking the efficiency of various garages in different locations working under the same management and preventive maintenance program.

Lew Hankins outlined road failure costs peculiar to the operation of the trucking outfit under his supervision.

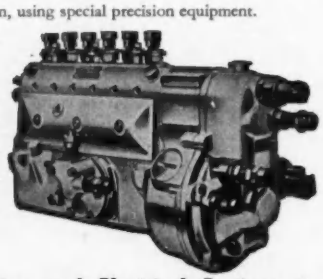
In a fleet of over 500 units, he said, his company receives approximately six road failures per day. Of these, three pertain to vehicles having to stop at a terminal for minor repairs, such as replacing bulbs, defective air lines, windshield wipers, etc. One road failure per day generally is engine trouble, such as motor skipping, fuel pump or carburetor trouble, burned out seal beams, etc. The other two are usually flat tires. Flat tires, he said, occur five times every three days.

Confidence Abroad

Transport operators all over the world have learnt to trust this sign.

In any language the letters on the C.A.V. sign stand for first-rate service facilities, maintained by highly-trained craftsmen, using special precision equipment.

Wherever vehicles fitted with C.A.V. Fuel Injection Equipment are exported — whether to Trondheim, Santiago, Hong-Kong or Sydney — there's a service agent or depot to give it the specialist attention needed for such high-precision equipment.



C.A.V.

Fuel Injection and Electrical Equipment

Service Depots throughout the World

C.A.V. DIVISION OF LUCAS ELECTRICAL SERVICES INC., NEW YORK 19, N.Y. Sales Office: 14820 DETROIT AVE., CLEVELAND 7, OHIO

174-344B

Describes Ford Engine For Cars and Light Trucks

• Southern California Section
P. Kyropoulos, Field Editor

Feb. 14—"The New Six Cylinder Ford Engine" was the topic of a talk presented by **Robert Stevenson**, assistant chief engine engineer, Ford Motor Co.

The public announcement of a new Ford six-cylinder engine for passenger cars and light trucks is the opening gun in a long-range program designed to provide all Ford products with lighter, more powerful engines with increased economy and better overall performance.

Of primary interest is the type of engine chosen for the new design. Although either L-head or overhead valve engines are suitable for use with present-day fuels, designers of any engine planned for a long production life must consider the fact that continual improvements in gasolines are the order of the day. Therefore, the overhead valve engine, with its more compact combustion chamber, became the logical choice, since it is so much easier to adapt the overhead valve engine to the higher compression ratios necessary to take advantage of gasolines with higher anti-knock ratings.

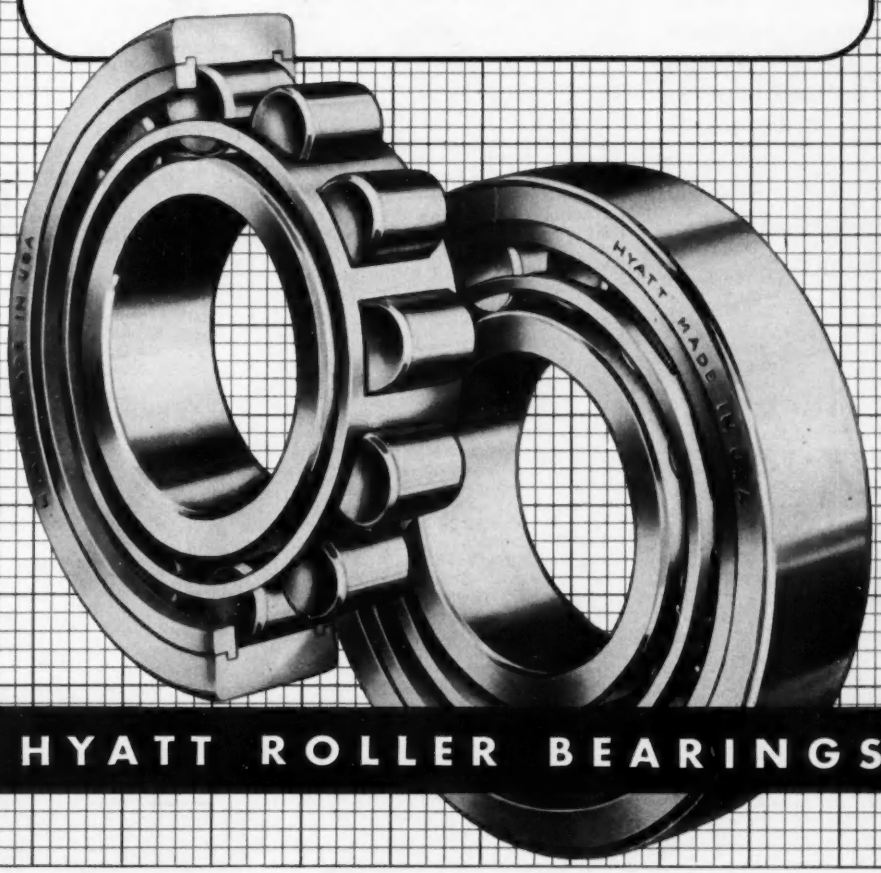
Among the many special features of the new Ford six-cylinder engine described by Stevenson are: valve rota-

For '52 · · · HYATTS As Usual

A review of the car, truck, and bus models for 1952 shows Hyatt Roller Bearings, as usual, predominating.

Automotive design engineers call for Hyatt applications in differentials . . . rear wheels . . . pinions . . . transmissions . . . steering gear and other positions. Hyatt makes various types and sizes of roller bearings to meet the requirements of the industry.

Over the years, Hyatts have proved their precision, quality and long-life—important factors appreciated by leading manufacturers. Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.



HYATT ROLLER BEARINGS

What do you know about the *Moly-sulfide* LUBRICANT?

You may have heard rumors of a highly successful solid-film lubricant which is giving remarkable results in the shop and in the field.

In one 40-page booklet we have collected 154 detailed case-histories describing how difficult lubrication problems have been overcome by molybdenum sulfide. If you wish to be up to date about this solid-film lubricant, write for a free copy now.

THE LUBRICANT OF MANY USES

Moly-sulfide

A LITTLE DOES A LOT

Climax Molybdenum Company

500 Fifth Avenue
New York City

SEND FOR THIS FREE BOOKLET TODAY

Name.....
Position.....
Company.....
Address.....

MOLY

SA-4 MS-3

tors of ingenious design; integral valve guides; full-flow oil filter; precision-molded alloy iron four-main bearing crankshaft, with provision made for future use of seven main bearings; a deep crankcase structure that provides a stiffer support for the crankshaft and extra-rigid engine mounting at the rear; a high compression ratio combustion chamber, designed for regular grade gasolines; and a shallow oil pan with a continuous, flat sealing surface.

Army Establishes New Heavy Duty Oil Standards

• Texas Section

A. P. Johnston, Field Editor

Feb. 8—Members of the Texas Section heard **Edward J. Bowhay** speak on the recent trends and developments in truck and bus lubrication. Bowhay, a mechanical engineering graduate of Clarkson College of Technology, is with the Texas Co., as assistant technologist in the Houston office of the Technical and Research Division.

Bowhay pointed out the needs for the recent improvements in lubricants and lubrication. Greater power with relatively slight increases in engine size, higher engine speeds, changes in fuel characteristics and new type transmissions have required extensive research and development in lubricants and lubrication practices. The millions of dollars spent each year by the truck and bus industry provide a potentially large field for savings from the use of improved lubricants.

Engine oils have received the greatest attention and the extent of their development is particularly significant. The use of additives to produce a heavy duty oil is now a recognized practice throughout the petroleum industry. Early development of heavy duty oils started with the lubrication requirements of the Caterpillar diesel engine. During World War II, these oils received prominent recognition with the establishment of U. S. Army Specification 2-104B.

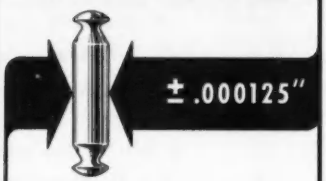
Subsequent improvements in engine design and changes in diesel fuel characteristics resulted in the development of "Supplement 2" and later "Supplement 1" type oils. Supplement 2 or Series 2 oil is for use in the supercharged Caterpillar diesel engine operating on high sulfur (1.0%) fuel. Supplement 1 oil falling between 2-104B and Supplement 2 oil performance is being used in non-supercharged diesel engines operating on high sulfur fuels. One of the latest developments is Military Specification MIL-0-2104 which now supersedes the obsolete 2-104B and raises the performance level of the basic heavy duty oil.

New and more useful classifications of these various types of engine oils are now under study with particular attention to the types of service which they must satisfy.

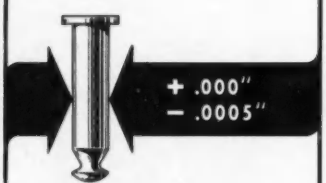
Special transmission fluids have been

HIGH MACH NUMBERS really mean— CLOSE TOLERANCE STRUCTURAL DESIGNS

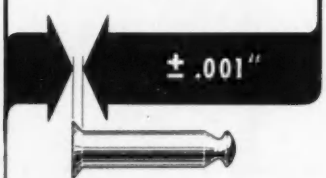
hi-shears mean— CLOSE TOLERANCE STEEL FASTENERS



The dowel pin features the closest tolerance of any aircraft fastener. Precision fit, flexibility to mold to irregular surfaces and elimination of spot-facing will reduce manufacturing costs.



The close tolerance shank answers design problems where close fit (either slide or interference) is needed in critical fitting attachments. Available in minimum hardness ranges of 125,000 psi and 160,000 psi.



The close tolerance head permits smooth surfaces, essential to transonic speeds and laminar flow. Rapid installation is gained without hand fitting in either cut-counter-sunk or dimpled holes.

U. S. and foreign patents — Trademark registered

THE *hi-shear* RIVET TOOL CO.
8924 BELLANCA AVENUE
LOS ANGELES, CALIF.

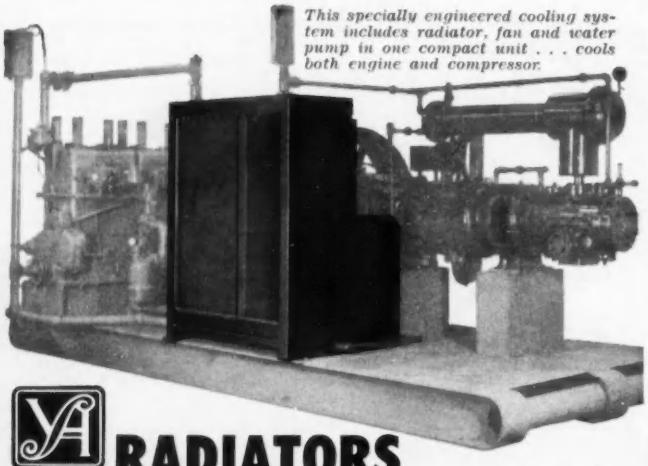
How many horses will he use in '62?
Tomorrow's farmer will want a lot more "horses" . . . and he'll want most of them on wheels! He'll want *horsepower* for farm engines that plow, sow or reap.
Improved castings, being designed *now* by Campbell, Wyant and Cannon, will make those engines better . . . will help the farmer do more. And such castings also mean new opportunities for farm equipment makers planning new machinery to increase farm mechanization still further.
Thus, the foundry serves the farm as well as the factory . . . and at CWC there is consistent emphasis on making this service more productive *today and tomorrow* through advanced metallurgical engineering, precision control and mechanized production.
CAMPBELL, WYANT AND CANNON FOUNDRY COMPANY, MUSKEGON, MICHIGAN
Foundries in Muskegon, South Haven and Lansing, Michigan
. . . serving the automotive, farm equipment, railroad and marine industries and the Armed Forces
CAST CYLINDER HEADS AND BLOCKS
CAST PISTONS
CAST CAMSHAFTS
CAST CRANKSHAFTS
CAST GEARS
CENTRIFUGALLY CAST CYLINDER LINERS
CENTRIFUSE BRAKE DRUMS
CWC
Since 1908

developed for the new fluid medium of torque multiplication. Gears in conventional transmissions are now being lubricated by an SAE 50 heavy duty engine oil instead of the SAE 90 and 140 grades of gear lubricants.

Rear axles with hypoid gears are increasing in use today and require an extreme pressure type gear lubricant. Two rear axle operating conditions, high speed-low torque and low torque-high speed, have resulted in the development of an all-purpose or multi-purpose gear lubricant to satisfy the requirements of both conditions. The latest Army specification for this all-purpose lubricant is MIL-L-2105.

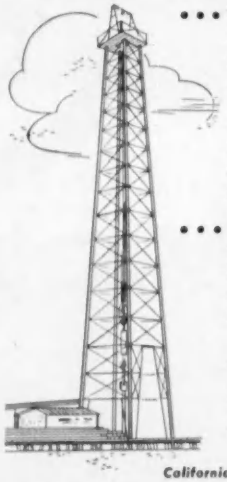
Proper packing of wheel bearings is one of the prime factors in satisfactory wheel bearing life. Of the two methods of packing wheel bearings, that provided by a good mechanical packer is generally considered better than hand packing. The latter method requires considerable skill and a certain knack to insure a completely satisfactory job. Some progress has been made in the sealing of wheel bearings to permit the use of a light gear lubricant.

Maintenance is the controlling factor in satisfactory lubricant performance. Long life of equipment is the result of "the right lubricant in the right amount at the right place at the right time."



This specially engineered cooling system includes radiator, fan and water pump in one compact unit . . . cools both engine and compressor.

YA RADIATORS



. . . designed for special conditions

Boosting natural gas pressure at the well or at critical points along the pipeline calls for real dependability in compressor units . . . and their radiators. They serve in isolated places where breakdowns mean double trouble. And they are often moved from one point in the line to another so they have to be able to withstand rough treatment.

. . . that need special engineering

To meet these demands, manufacturers of pipeline equipment come to Yates-American . . . where special engineering to meet special conditions is a tradition.

Whatever your product — compressor, excavator, power plant, truck, tractor or locomotive — you can be sure the radiator will be engineered to match it if you come to Yates-American. Write today for further details.

California Representative: E. E. Richter & Son, Emeryville, California

YATES-AMERICAN MACHINE CO.

HEAT TRANSFER PRODUCTS DIVISION • BELOIT, WIS., CHICAGO, ILL.

Lists Advantages Of Power Brake System

• Kansas City Section

Paul L. Dumas, Field Editor

Feb. 25—"Vacuum-hydraulic power systems combine all the separate components of the older type vacuum systems into a self-contained unit," said **W. R. Williams**, executive engineer, Bendix Products Division of Bendix Aviation Corp.

As a foundation for his enlightening discussion on present-day power braking systems, Williams quickly reviewed pre-World War II braking systems of the plain hydraulic and vacuum or air-operated hydraulic or mechanical types. He pointed out that the power brake of the day then consisted of a number of separately mounted assemblies which were mechanically coupled to either the hydraulic or mechanical brakes and that certain disadvantages existed: (1) Inefficiency because of mechanical losses; (2) Possible inconsistent operation because of variable friction and wear in external moving parts; (3) The necessary proximity of power equipment to other parts of the brake system sometimes made it impossible to provide adequate power because of space limitations; (4) The equipment, as a rule, had to be "designed" into each installation; (5) Service and maintenance problems were major because of the specialized nature of the installation on vehicles of varied manufacture and model; (6) They were inflexible from the standpoint of interchange of power equipment to suit varied braking requirements.

The "modern" vacuum-hydraulic system consists of three major parts—the power cylinder, the hydraulic cylinder, and the control valves, which are all grouped in one unit—giving the following desirable characteristics:

(A) Being a "one-unit" system, it eliminates external moving parts and improves the efficiency because it is hydraulic rather than mechanically connected.

(B) Since it is a sealed unit, the system is protected against dirt, water and other contamination and the results are less service and maintenance requirements.

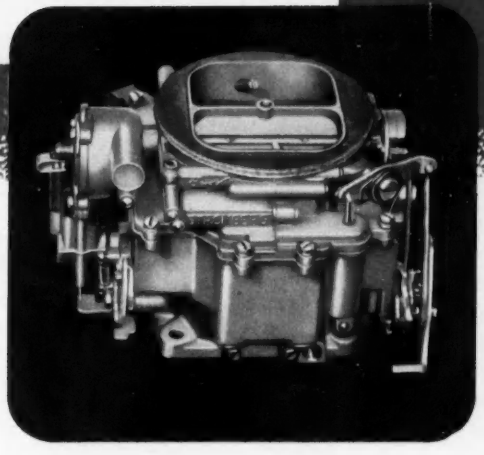
(C) Its "one-unit" characteristic permits easy field adaptation to non-

STROMBERG

The Quality Name in Carburetion

PRESENTS

Aeroquad



The new four barrel Carburetor

that gives Substantially Increased Horsepower
Smoother Operation . . . Improved Economy

Stromberg now brings you a carburetor of such advanced design that it is surely destined to be the accepted standard of tomorrow's car.

Born out of Stromberg's constant search for higher efficiency in carburetion—a research program that began 40 years ago and has never since stopped nor slowed down—the new four-barrel Aeroquad Carburetor provides unequalled engine performance.

The new Aeroquad helps to provide instant hair-trigger response and acceleration when the driver demands it! It makes that extra surge of power at high speeds . . . so often needed for passing . . . a firm reality. In every driving situation—on crowded city streets . . . on fast-moving super-highways . . . under heavy load—the Stromberg* Aeroquad Carburetor gives added engine power, silky-smooth performance, and reduced operating costs.

Make your choice Stromberg—the name you can depend on for the finest in carburetion. *REG. U. S. PAT. OFF.

ECLIPSE MACHINE DIVISION OF

• Standard Equipment Sales: Elmira, N. Y. • Service Sales: South Bend, Ind.
Export Sales: Bendix International Division, 72 Fifth Avenue, New York 11, N. Y.

BENDIX AVIATION CORPORATION

FEL-PRO offers engineering help . . .

that extends from DESIGN and MATERIAL SELECTION to the FINAL INSTALLATION

FEL-PRO is always glad to work with engineers in the design and selection of special gasketing materials to solve a difficult sealing problem. But now, FEL-PRO carries this engineering service a step further, to insure proper installation of gaskets. A new manual, the first of its kind ever offered, is now available to automotive service shops and mechanics. This new FEL-PRO Gasketing Manual shows how to install gaskets to "Insure Praise-Winning Jobs" everytime. It shows step-by-step procedures in simple, easy-to-follow language. Engineers who are interested in seeing a copy of this new FEL-PRO Gasket Manual may obtain free copies by writing:

FELT PRODUCTS MFG. CO., 1550 Carroll Ave., Chicago 7, Ill.

FEL-PRO Utilize Newest Materials ENGINEERED Specifically designed for your product **gaskets**

5HM7

DESIGNERS & ENGINEERS

★ Aeronautical ★ Electronic ★ Mechanical
★ Hydraulic ★ Metallurgical
and ★ Chemists

DID YOU KNOW THAT

Hamilton Standard Division

DESIGNS DEVELOPS AND MANUFACTURES

★ Jet Fuel Controls ★ Aircraft Air-Conditioning Units
★ Jet Engine Starters ★ Variable Displacement Pumps
as well as Propellers for Reciprocating and Turbine Engines

IF YOU ARE QUALIFIED AND WANT

Excellent Pay
Finest Working Conditions
Opportunity for Advancement
Insurance and Retirement Benefits

PLUS an opportunity to work in a brand-new 700,000 square-foot plant at Bradley Field, Windsor Locks, Connecticut, now nearing completion . . . expanded research and development facilities . . . latest types of equipment.

MAIL YOUR RESUME TO: EMPLOYMENT SUPERVISOR, DEPT. B,

HAMILTON STANDARD EAST HARTFORD CONNECTICUT UNITED AIRCRAFT CORPORATION

HAMILTON STANDARD

One Of The Four Divisions Of United Aircraft Corporation

EAST HARTFORD, CONN.

powered or improperly-powered vehicles.

(D) It permits relatively easy interchange of power units.

(E) It makes adequate braking power available since it can be mounted anywhere on the chassis and space limitations are no longer a factor.

"From the standpoint of brake performance," said Williams, "there are five important vacuum hydraulic power system characteristics: physical effort on the pedal and braking effort created by power are additive; application of brakes by physical effort alone is always possible; the intensity of the brake stop can be accurately controlled by the driver; no special braking procedure is required to make a stop; and pedal pressures are reduced."

Slides were used to emphasize important points throughout the discussion. Williams closed the meeting by handing out folders describing the Bendix power brake system and exhibiting a cutaway of a typical Hydrovac unit.

Untapped Oil Reserves Available, Barnard Says

• New England Section

George T. Brown, Field Editor

Feb. 8—Research and progress in the field of engineering are closely allied. Progress depends not only on the amount, but on the nature of the research.

This was one basic fact emphasized by SAE President **D. P. Barnard** to the large gathering at the Graduate House at M.I.T. which assembled to hear him.

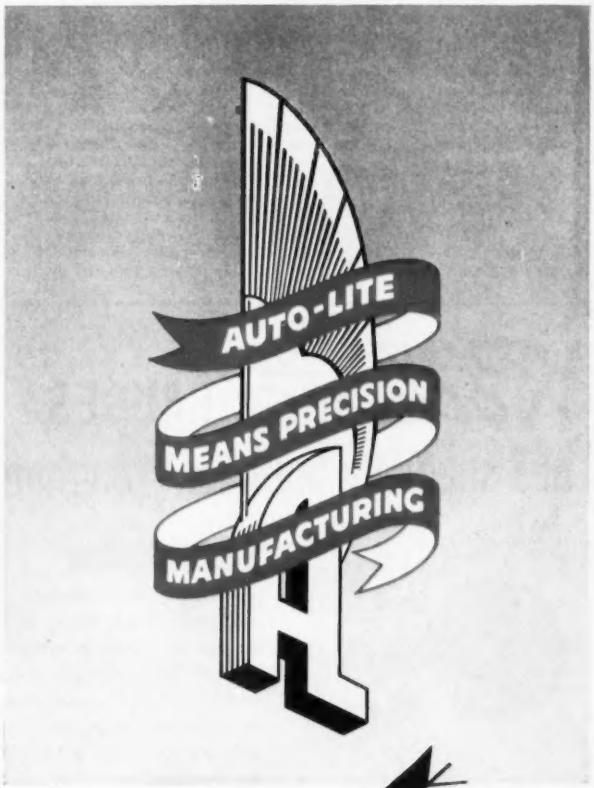
The cocktail hour preceding the dinner was sponsored by O. E. Johnson, Brake and Electric Sales Co.

Harry Stanton, automobile editor of the Boston Globe, lucidly described the events of interest arising from his visit to the SAE 1952 Annual Meeting. He declared that he would continue to exert what influence he could in the hope that the 1954 SAE National Transportation Meeting will be held in Boston.

Norman G. Shidle, editor, SAE Journal, introduced by SAE Councilor Robert Lybeck told the New Englanders of the significant contribution made to SAE publications by the Readers Committees of the SAE Publication Committee. In bringing to light these inconspicuous but significant groups, Shidle declared that no single element in the SAE procedure contributes more in keeping high the quality of SAE publications. The personnel of these committees, he said, includes some of the best technical experts in the world.

Dr. Barnard talked chiefly of the progress which has been made in development of crude oil research and petroleum cracking methods. He pre-

You're always right with



AUTO-LITE

AUTO-LITE works to serve the nation's needs in peace and in defense. In 28 great Auto-Lite plants from coast to coast, Auto-Lite produces more than 400 products which are original equipment on many makes of America's finest cars, trucks, tractors, airplanes and boats. Their 40-year record of dependable performance is summed up in the phrase, "You're Always Right With Auto-Lite."

THE ELECTRIC AUTO-LITE COMPANY
Toledo 1, Ohio Toronto, Ontario

Spark Plugs · Fuel Pumps · Batteries · Bumpers · Generators · Speedometers
Horns · Switches · Moulded Plastics · Speedometer Cable
Starting Motors · Ignition Units · Instruments & Gauges · Windshield Wipers
Lighting Units · Wire & Cable · Gray Iron Castings
Window Lifts · Metal Fabricated Assemblies · Zinc & Aluminum Base Die Castings

sented a variety of factual evidence and slides to illustrate his points.

The geologist and geophysicist, he said, have gotten away from the old "wildcat" methods and are now giving much more accurate bases for well drilling by using four basic methods:

1. Seismic sounding
2. Gravitometer
3. Magnetometer
4. Electric logging

It is generally stated, Dr. Barnard pointed out, that there is in this country a 12-years' reserve of petroleum, an estimated 26 billion barrels. This, however, is not the total crude oil reserve. If more money were released for exploration, he emphasized, greater quantities could be obtained in a shorter period should the nation's requirements necessitate it.

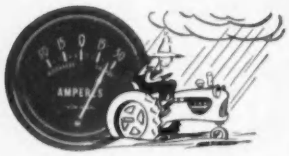
Present processing cost levels and present practices produce about 25% of the oil known to be in the formations. Besides the possible recovery of part or all of the remaining 75% from the present wells by gas-driven apparatus, water-flooding methods, or underground explosions to loosen previously untapped pockets, totally new fields could be developed, Dr. Barnard said. Such new fields as the Williston basin, which extends from the United States into Canada, would immeasurably increase the reserve period or supply more barrels during the same period.

Dr. Barnard described also the progress of refining research from the early '20s through the many stages of development up to the present. His description of refining illustrated the changes from the use of the Burton process shortly before World War I to the various catalytic, polymerization, and other processes in wide use today.

Dr. Barnard stated that the development of oil from shale and coal is not economically feasible at present.

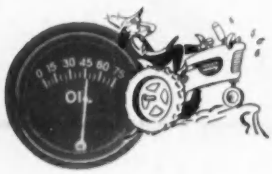
In conclusion, he questioned whether there will be sufficient future engineering manpower of the required standards of ability to meet the growing requirements of advanced research. The problem is particularly acute, he said, because of the prospective drain of such talent by the armed forces.

Rochester GAUGES
are specially built for "roughing it"



ROUGH WEATHER

No danger of condensation or dirt hindering the dependably accurate performance of Rochester ammeters, temperature and pressure gauges. Fogproof—their easy-to-read dials are hermetically sealed behind extra strong glass crystals. No plastic substitutes, no discoloration.



ROUGH GOING

Even your smoothest riding tractors have to take a lot of hard knocks—the tough, but sensitive movements of Rochester Gauges are protected with vibration and pulsation dampeners.

ROUGH USE

Always working under heavy load, temperature and pressure are high and critical. That's why tractor engines are specially built, as are Rochester Gauges to protect them.

No wonder practically all leading tractor manufacturers have been specifying Rochester Gauges as standard equipment for over 35 years.

Rochester Manufacturing Company, Inc.
21 Rockwood St., Rochester 10, N. Y.
DIAL THERMOMETERS GAUGES AMMETERS

Outlines Problems Of Roller Bearings

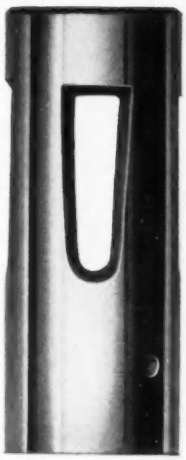
• Southern New England Section
R. Bradley Fisher, Assistant Field Editor

March 5—Eighty-five members and guests of Southern New England Section heard **Ralph H. DuBois**, Philadelphia representative of Bower Roller Bearing Co., speak on "Interesting Applications of Roller Bearings."

DuBois opened his talk with several slides of roller bearings showing various designs, applications, and the appearance of some failures of roller bearings. He said that as far as he knew there had never been a failure in aircraft bearings which could be attributed to fatigue—that all the failures had been caused by the cages. According to DuBois the Germans, toward the end of World War II, were using cages of oil-impregnated wood but he felt that this was done to save critical materials.

Skidding of the rolls, which is evidenced by a frosty or etched condition of the races, is believed to be caused by high speeds, light loads, poor lubrication, misalignment, and perhaps too much radial clearance. DuBois cited a case in which a monel cage with no oil, high speeds and light loads was run for 22 hours before failure. Silicon-iron-bronze appears to be a good choice of material for cages, but this loses some of its physical properties at 600 to 700 F. Frosting (small particles of metal torn out of the bearing race) will sometimes appear on a bearing in

the chilled-iron face gives Eaton Tappets superior load-carrying capacity and longer life



To keep pace with the requirements of today's higher-speed, higher-compression engines, Eaton has developed special foundry facilities to produce chilled-face tappets with essential hardness and wear-resistant characteristics. Eaton offers volume-produced, volume-priced, lightweight tappets capable of carrying excessively high loads. From the ladle to final inspection, the wear-resistant hardness of the face and the over-all quality of Eaton tappets are guarded by precise metallurgical control.

You can utilize Eaton's long experience in this field by giving our engineers an opportunity to work with yours in the early stages of design.

EATON MANUFACTURING COMPANY

CLEVELAND, OHIO

SAGINAW DIVISION: 9771 FRENCH ROAD • DETROIT 13, MICHIGAN

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

For Better Hydraulic Brake Cylinders

EATON

Permanent Mold Gray Iron Castings

Send for your copy of the illustrated booklet, "A Picture Tour of the Eaton Permanent Mold Foundry."

Free machinability
Dense, homogeneous structure
Freedom from leakage under pressure
Machines to high, mirror-like finish
Properly annealed; no growth or distortion after machining

EATON MANUFACTURING COMPANY
CLEVELAND, OHIO
FOUNDRY DIVISION: 9771 FRENCH ROAD • DETROIT 13, MICHIGAN

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springlites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

the first few minutes of running and then heal itself and run for many hours.

DuBois said that he had examined many European-made bearings and the quality and workmanship—particularly in the tolerances held—did not come up to the standards held in this country.

A great deal of experience is needed with bearings between the sizes of 100 to 200 mm rotating at 15,000 rpm. It was felt by the speaker that a much better job could be done on bearings if the manufacturer knew exactly what maximum misalignment to expect, what temperature differential between the outer and inner races would occur, and what maximum temperature to provide for.

Looking into the future, DuBois said that the steel now in use for the races and rollers could probably be used but these materials must be stabilized at a higher temperature. More development work must be done on cages, and new lubricants must be developed. He concluded that testing programs that up to now have not been possible economically should allow the trial of new cage configurations.

Describe Construction Of Wichita's New Airport

• Wichita Section

Chuck Allison, Field Editor

Feb. 27—The new Municipal Airport was the subject of a talk given by **O. O. Ediger,** consulting engineer for the new Wichita Municipal Airport. He was assisted by **W. R. Fleck,** chief engineer—Board of Park Commissioners and **Roy Colvin,** architect of the Terminal Building. The subject was naturally based on problems unique to Wichita, two main problems being the location of the airport and the financing of the project.

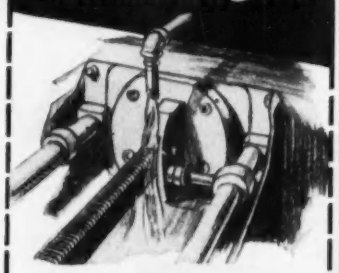
The following are some of the requirements which had to be met in choosing a suitable location: CAA regulations require that the main runway must be at least ten miles from, and parallel to, the old airport runway. It must be high enough to prevent flooding. It must be conveniently accessible from town, and a railroad should be near by. The site finally chosen is five miles west of Wichita.

The next phase of the talk dealt with the general construction and layout of the airport. The airport drainage system was designed to handle 2 in. per hour of rain. Storm sewers are used to accomplish this. The area between the runways are sumped for ponding action to take care of rain in excess of this amount.

The Terminal Building is to be of ultra modern design. Concrete construction will be used, with large glass areas on the airport side to give every-

O&S BEARINGS
NON-METALLIC • SELF LUBRICATING
RADIAL LOAD
CORNER LOAD
AXIAL LOAD
O & S has the RIGHT ANGLE on BEARINGS
. . . for combined axial, radial and corner loads
NYLON INSERT
All Purpose Bearing...
AXIAL LOAD
CORNER LOAD
RADIAL LOAD
LUBRICANT IMPREGNATED FABRIC
By combining the inherent characteristics of the efficient O & S lubricant impregnated bearing material and the recently developed nylon bearing material we have found the answer to the problem of simultaneously combined radial, axial and corner loading.
If you have a problem that involves all three—write for Bulletin 153.
NeverOil
SINCE 1919
O & S BEARING CO.
303 SOUTH LIVERNOIS • DETROIT 17, MICHIGAN

TOUGH or EASY machining...



MORE THAN A "COOLANT" IS NEEDED

LITERALLY thousands of plants will testify that Stuart cutting fluids have been their only answer on *really tough* machining jobs. The research and experience that makes Stuart a leader on the tough jobs pays real dividends on the easy jobs. Stuart knows that *more than a "coolant" is needed* — that cooling, lubricity and anti-weld characteristics must be combined in a cutting fluid if optimum finish, tool life and production are to be secured.

This doesn't mean that you must have a different cutting fluid for every job, but it does mean you need a cutting fluid that is *right* for the job.

Send for NEW BOOKLET "MORE THAN A COOLANT IS NEEDED" and ask a Stuart representative to show you how the planned application of Stuart cutting fluids will give you more output, longer tool life, better finish and lower cost.

Offices in Principal Industrial Centers

TIME-TESTED

D.A. Stuart Oil Co.

EST 1865 LIMITED

2727-51 S. Troy St., Chicago 23, Ill.

body a view of the activities on the field, including those eating in the dining room.

The passengers will go through a tunnel via escalators to board their airplanes. The control tower will be a seven-story affair and will house all the government offices.

Due to unexpectedly good weather, the airport construction is actually ahead of schedule at this time.

An added feature of the meeting was a very interesting film on the B-36 Bomber, entitled "Target—Peace."

Gives Case for Turbines For Use in Small Aircraft

• Western Michigan Section
Tom Reeves, Field Editor

Jan. 23—**Carl F. Bachle,** vice president of Continental Aviation and Engineering Corporation, spoke on "The Case For Turbines In Small Aircraft." Steady progress has been achieved in load carrying capacity, economy and speed of personal aircraft until recent years. The advent of the turbine now opens a new avenue of development which should allow this progress to continue. Turbines can result in increased comfort, safety and speed through noise and heat reduction, better vision, lowering interval of weather prediction and ability to fly over adverse weather areas, Bachle said.

Fuel consumption is at present greater than that of piston engines. But the application of turbines to production aircraft should not be delayed because of this, Bachle said, as superior performance can otherwise be obtained. Final availability will depend upon public demand, and how soon they are offered will depend upon attractiveness of the improvements offered.

For many military applications turbines are unexcelled and so their first use will be here. Final costs should be the same or lower per horsepower compared to conventional piston engines.

"Prairie Farmer" Editor Tells Farm Machinery Needs

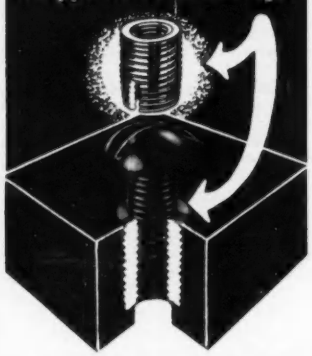
• Chicago Section
P. P. Polko, Field Editor

Feb. 12—The Chicago Section meeting tonight was honored by the presence of **Dr. D. P. Barnard,** 1952 SAE President. In reminiscence of his early SAE activity, dating back to the 1929-30 period when he was Chairman of the Chicago Section, Dr. Barnard praised the constant vigorous growth of the Society membership. He compared attendances of Section meetings, which swelled from an average of 30 in 1930 to 300 or 400 in 1952.

The presentation of "What Do

TAP-LOK INSERTS

for original installations and stripped thread salvage



Tapped threads that strip easily are a headache to customers. Thread failure in light metals, plastics and similar materials can be prevented by the Tap-Lok Insert, a hard steel bushing that increases the shear area.

These Inserts are widely used for original installation because, being self-tapping, they save many manhours in assembly. They are quickly installed with a simple driving tool into a cored or drilled hole equal in size to a tap drill hole for the external thread of the Insert. They hold rigidly in position and do not become loosened when the male part of the fastening is removed.

The Inserts are also extensively used for the salvage of threads stripped in assembly. Many manufacturers are using them for this purpose to reduce the high cost of rejects.

Send for samples and descriptive folder.

•

Also manufacturers of Groov-Pins for positive locking press fit.

GROOV-PIN

GROOV-PIN CORPORATION

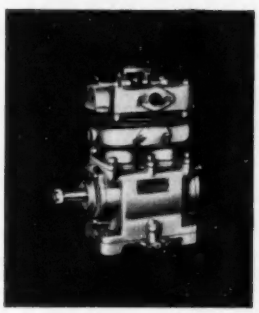
1123 Hendricks Causeway, Ridgefield, N. J.

Bendix Westinghouse

THE WORLD'S MOST TRIED AND TRUSTED

AIR BRAKES

You're looking at . . . the World's Toughest Proving Ground for any Braking System!



THE BENDIX-WESTINGHOUSE COMPRESSOR—heart of the air brake system—performance proven over more miles on more installations than any other compressor available!

That's right—the bus industry, due to the very nature of day after day city driving . . . **requiring a truly terrific number of braking applications per mile** . . . is recognized as the world's toughest test for any braking system. And over the years the men who build and operate the nation's buses have made Bendix-Westinghouse Air Brakes first choice for this rough and rugged braking chore. But what does this mean to you? It means when you specify Bendix-Westinghouse Air Brakes for your trucks as well as your buses, you specify a **completely proven braking system** ready to deliver full power and performance under any and all driving situations. What's more, it means you specify the world's finest compressor—built on the same **proven reciprocating piston principle** as the engines in your vehicles—with a demonstrated ability to maintain full air pressure under even the most gruelling conditions—for **longest service life at lowest maintenance cost!** Take advantage of it—specify Bendix-Westinghouse, the world's most tried and trusted air brakes!

BENDIX-WESTINGHOUSE AUTOMOTIVE AIR BRAKE COMPANY

ELYRIA, OHIO BERKELEY, CALIF.

Farmers Want and Need From Their Farm Machinery" by **Paul C. Johnson** won the close attention and interest of everyone, at the meeting. Johnson, editor of "Prairie Farmer" in Chicago, is a specialist in agricultural subjects and is well qualified to tell farm machinery engineers what must be done to further improve their products.

The guest speaker's preliminary observations dealt with the productiveness of American agriculture. Only as recently as twenty years ago our country shifted from an agricultural to an industrial nation. At the turn of the century we were still overwhelmingly agricultural. One hundred years ago there were four people engaged in agriculture to every one in industry and commerce. At present, only 17% of our people are working in agriculture. In the corn belt, soon only one family in ten will be required to furnish food and fiber for itself and the other nine families.

The productivity of American agriculture has been fostered by 1) incessant scientific research in agriculture and remarkable success in translating the principles into practice by educational means, 2) a high degree of curiosity and aptitude on the part of the farmer, and 3) better and better farm machinery.

Farm machinery research has been relatively limited in our agricultural experiment stations, partly because of a lack of funds and facilities. Because the machinery industry has been moving so fast of its own accord, tax money has been directed toward research to improve plant varieties, control plant and livestock diseases, rather than for machinery research.

There is a need for agricultural research on the mechanical problems of farming, however. The rapidly-moving, highly-competitive machinery manufacturers must consult with independent research men who look at farm mechanization problems with tough minds, Johnson said.

Recently the "Prairie Farmer" canvassed a thousand Illinois active farmers and farm boys by mail to determine what is desired in farm machinery of the future. The first phase of the survey had reference to the tractor. The editor placed equal emphasis on the opinions of the farm boy and his father, because farm boys are the mechanics on modern farms and have a real influence on their fathers' decisions.

The survey indicated an average of almost two tractors per farm in the corn belt on a group of farms averaging about 235 acres each. Many farms have three or four tractors.

Asked what major machines needed least improvement, the farmers listed the tractor and the plow. The least satisfactory units were the combine and corn picker, Johnson reported.

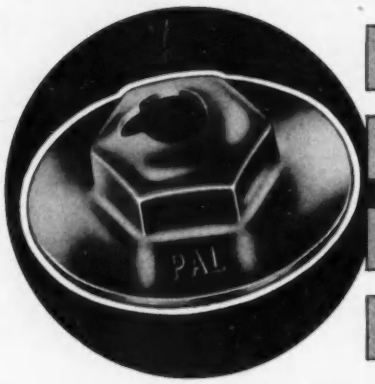
The farmers were asked what they wanted most in tractors, speed and power, or fuel economy, or long life. Both boys and men preferred speed and power, two to one over fuel economy and durability. To the inquiry as to what would be the popular tractor fuel of the future, came the answers of diesel fuel and LP gas.

The survey disclosed a definite trend toward the three-plow tractor. Special attention to developing a versatile three-plow tractor that will do a great many farm jobs seems to be indicated.

The "Prairie Farmer" survey questioned what type of gadgets and special features in tractors the farmers are willing to buy. In order of importance the items were: 1) electric starters, 2) power take-off, 3) head and rear lighting units, 4) electric clock to record hours and other data, 5) flashing red light for highway use, and, 6) overdrive. Most farmers want transmission with six speeds forward, some want nine.

Johnson stressed the importance of the fatigue factor in tractor operation because it is closely related to accident

SLASH ASSEMBLY COSTS



-- on Moulding Strips and Deck Handles

-- on Tail and Parking Lights

-- on Hood Ornaments and Nameplates

-- on Instrument Mountings

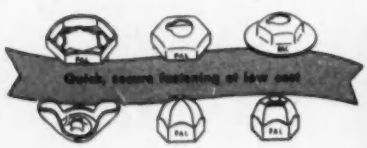
Washer Type PALNUT LOCK NUTS

Handle ONE part instead of THREE

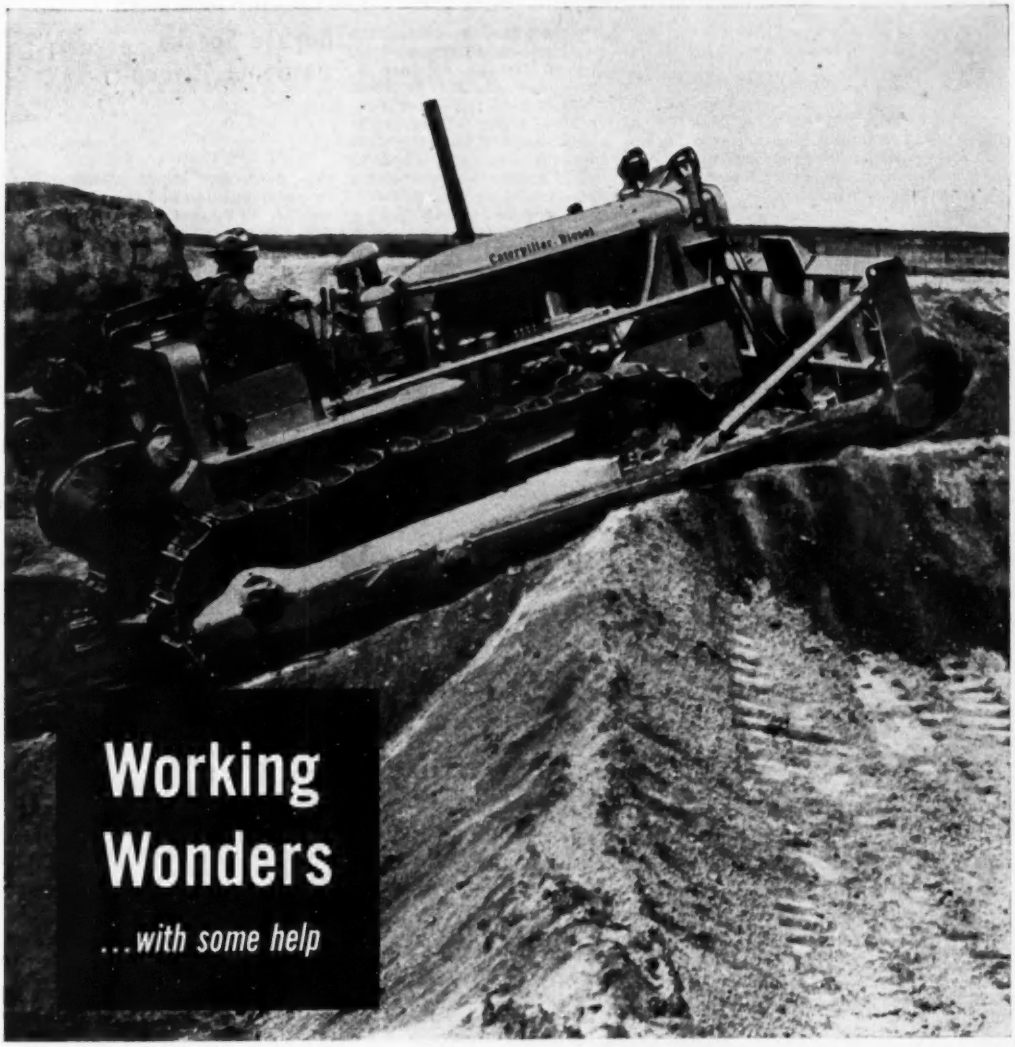
"75% reduction on assembly costs" reports one manufacturer

Low-cost, one-piece Washer Type PALNUT Locknuts do the job of an ordinary nut, lockwasher and plain washer combined. You save parts and handling operations—get speedy assembly with hand or power drivers. Resilient lock greatly reduces stud breakage during assembly. PALNUT double-locking spring action holds tight under vibration. Built-in washer spans holes and slots. Wide range of standard sizes. Send details of assembly for free samples and literature.

The PALNUT Co 70 Cordier St., Irvington 11, N. J.
Detroit: 730 West Eight Mile Road



PALNUT
TRADEMARK
LOCK NUTS



Working Wonders

...with some help

The tremendous strength of those big yellow machines built by Caterpillar demands superior strength in each component part.

Since 1923, BCA Bearings have been original equipment on Caterpillar Diesel Tractors . . . Motor Graders . . . Earth-moving Equipment. For three decades, BCA engineering has contributed to Caterpillar's enviable reputation for outstanding performance on the toughest jobs.

Whatever *your* bearing requirements—specify the best—BCA Bearings. They are *performance* proved.

BEARINGS COMPANY OF AMERICA

LANCASTER · PENNSYLVANIA

BCA *Radial, Angular, Contact-Thrust BALL BEARINGS*

rate. More attention should be paid by tractor designers to ease of getting on and off a tractor.

In the consideration of mounted versus hitched implements, the preference is unquestionably for farm tools that can be mounted right on the tractor. Farmers believe present attached implements are not too difficult to put on and take off, Johnson said, but they do want more pull-pins and fewer bolts, better stands for holding mounted machinery when off the tractor, built-in jacks to line up equipment, and more sliding and less lifting.

Pertinent informative comments were given by meeting chairman M. R. Bennett, retired Harvester executive A. W. Scarratt, and Bendix Products Division chief engineer R. A. Goepfrich. Bennett explained how a long useful life of farm machinery was attainable by designing for easy replacement of high mortality parts. Scarratt related the significant advancement made in implement operation through introduction of hydraulic controls, and Goepfrich told of the constantly increasing demand for better tractor brakes during the past decade.

these FLEET-PERFORMANCE MILESTONES are further proof of the ENGINEERING-SOUNDNESS behind DELUXE FULL-DEPTH FILTRATION!

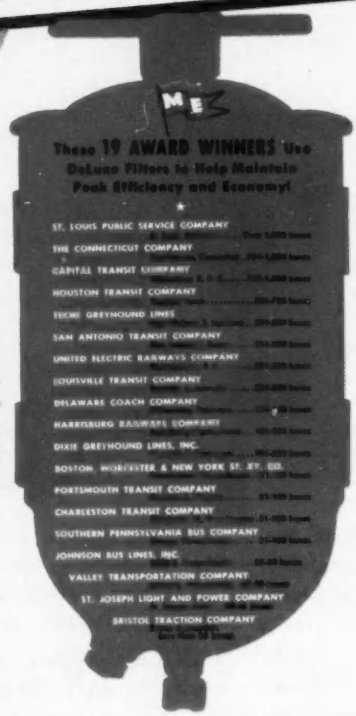
When the men responsible for fleet upkeep choose DeLuxe Filters year after year, then win efficiency awards for engine maintenance year after year, the soundness of the DeLuxe approach becomes evident. DeLuxe pioneered the now-imitated Full-Depth Filtration Principle over 17 years ago. In addition, DeLuxe engineers developed such oil-cleansing advancements as the exclusive spring-and-cone cartridge, the new removable sump and many other refinements important to efficient engine operation.

Again!

19 out of 23 BUS TRANSPORTATION, 1951 AWARD WINNERS are DELUXE FILTER USERS!

This achievement proves again the value of the DELUXE Long-Oil-Travel Method. Year after year, the majority of the winners of these Maintenance Awards have been DELUXE Users. It is another proof that men who know the answers prefer DELUXE Oil Filters with the exclusive Spring-and-Cone Cartridge.

Fleet-proved results like these point to bigger fleet sales for DELUXE Jobbers. Get the facts TODAY! Write DELUXE PRODUCTS CORP., 1413 Lake St., La Porte, Ind.


These 19 AWARD WINNERS Use DeLuxe Filters to Help Maintain Peak Efficiency and Economy!
ST. LOUIS PUBLIC SERVICE COMPANY
THE CONNECTICUT COMPANY
CAPITAL TRANSIT COMPANY
HOUSTON TRANSIT COMPANY
TEXAS GREYHOUND LINES
SAN ANTONIO TRANSIT COMPANY
UNITED ELECTRIC RAILWAYS COMPANY
LOUISVILLE TRANSIT COMPANY
DELAWARE COACH COMPANY
HARRISBURG RAILWAYS COMPANY
DIXIE GREYHOUND LINES, INC.
BOSTON, WORCESTER & NEW YORK ST. RY. CO.
PORTSMOUTH TRANSIT COMPANY
CHARLESTON TRANSIT COMPANY
SOUTHERN PENNSYLVANIA BUS COMPANY
JOHNSON BUS LINES, INC.
VALLEY TRANSPORTATION COMPANY
ST. JOSEPH LIGHT AND POWER COMPANY
BRISTOL TRACTION COMPANY

HEART of the DELUXE Filter is the Genuine DELUXE CARTRIDGE

The genuine DELUXE Cartridge is the only Cartridge with the Spring-and-Cone! It is the only Cartridge that will give full-depth genuine DELUXE oil-cleansing action in the DELUXE Filter—don't offer substitutes!

DELUXE Oil Filter

DOES MORE THAN STRAIN OIL — MORE THAN FILTER OIL

ACTUALLY CLEANSES OIL

R-5744NSSAE

Bugbee Speaks At Denver Group

• Denver Group

Dick Arnold

Feb. 6—A fine crowd attended the February meeting of Denver Group to hear **J. T. Bugbee**, research engineer and technologist of Texas Co., who has recently been engaged in coordinating the development of automotive automatic transmissions and the fluids necessary to their operation.

Bugbee first covered the fundamental operations of all types of torque converters and automatic transmissions and related devices. A thorough explanation of all types in present use was illustrated with slides of schematic diagrams and cutaways which greatly simplified the many complexities of such units.

Bugbee concluded that automatic transmissions are here to stay, due partly to the preferences of the increased number of lady drivers. He also gave a brief resume of improvements on transmissions in the 1952 cars.

The paper was followed by a lively question session in which Bugbee gave some "off-the-record" answers.

Bugbee was guest of honor at a Governing Board dinner preceding the meeting, and next day was taken on a tour of Denver's points of interest.

Urge Simpler Design To Lower Helicopter Costs

• Metropolitan Section

Feb. 7—Significant engineering and dramatic reports of both combat and civilian uses of helicopters painted a bright future for this type of aircraft at this season's largest Metropolitan Section dinner.

More than 300 members and guests heard **Dr. Igor Sikorsky, Joseph Garside**, president of Wiggins Airways, and **Col. Keith S. Wilson** say, among other things that:

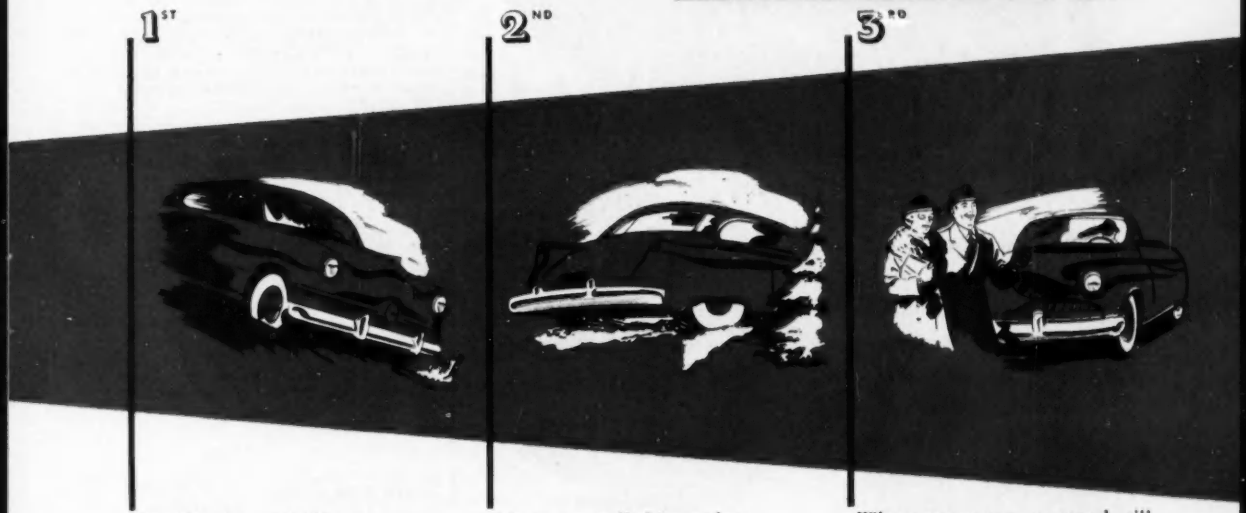
• Outstanding advances in aeronautics during this decade have been man's elimination of both the supersonic and low-speed barriers in flight;

• Pressure from field commanders brought wide-range values of helicopters to the attention of top military commands, and their performance has impressed the public;

• A ten-year development program in New England promises to prove the value of these machines as feeders to airlines;

• Accelerated development of the conventional type of helicopters as well as the gyrodyne and the so-called

three things you will like Better about BORG-WARNER automatic transmissions



You'll find you still have full braking power going down hill.

If you get stalled in mud or snow, you still have that necessary "rocking" ability to pull out.

When you stop—you stand still. There's no creeping—no need to keep your foot on the brake.

ENGINEERING MAKES IT WORK

PRODUCTION MAKES IT AVAILABLE

Almost every American benefits every day from the 185 products made by

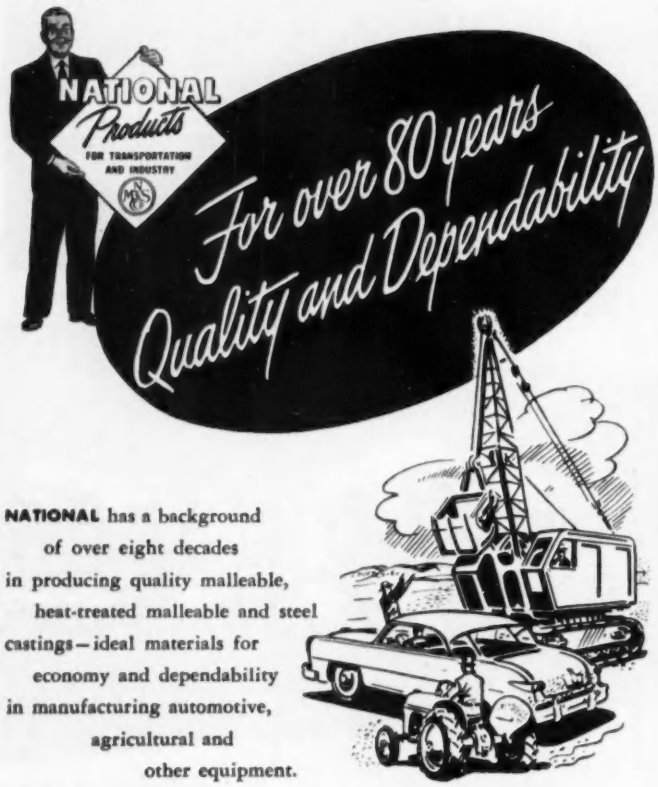
BORG-WARNER

THESE UNITS FORM BORG-WARNER, *Executive Offices, Chicago:* BORG & BECK • BORG-WARNER INTERNATIONAL • BORG-WARNER SERVICE PARTS • CALUMET STEEL • DETROIT GEAR • DETROIT VAPOR STOVE • FRANKLIN STEEL • INGERSOLL PRODUCTS • INGERSOLL STEEL • LONG MANUFACTURING • LONG MANUFACTURING CO., LTD. • MARBON • MARVEL-SCHEBLER PRODUCTS • MECHANICS UNIVERSAL JOINT • MORSE CHAIN • MORSE CHAIN CO., LTD. • NORGE • NORGE-HEAT • PESCO PRODUCTS • ROCKFORD CLUTCH • SPRING DIVISION • WARNER AUTOMOTIVE PARTS • WARNER GEAR • WARNER GEAR CO., LTD.

Today

on your new car you want Automatic Transmission. Once you get all the facts about Borg-Warner Automatics —beautifully engineered and produced by B-W's Detroit Gear and Warner Gear Divisions—you will want to make sure you enjoy the everyday driving benefits of B-W engineering and production.

For Automatic Transmission at its perfected best—for the simplest, most advanced no-shift drive ever developed —make certain the car you select is Borg-Warner equipped.



NATIONAL has a background of over eight decades in producing quality malleable, heat-treated malleable and steel castings—ideal materials for economy and dependability in manufacturing automotive, agricultural and other equipment.

NATIONAL'S unparalleled experience—coupled with a continuing metallurgical research program, rigorous quality control standards, and completely mechanized foundries in strategically located cities—is at your disposal.

Sales offices and engineering facilities are located at all five plants listed below.

SEE "This Moving World"

A 16mm technicolor film. Narrated by Edwin C. Hill, this 27-minute film tells how malleable iron is made . . . tested . . . used . . . how its production economy, ductility, machinability, toughness will give you a better finished product. Available for group showings. A-5017

PLANTS LOCATED IN
Sharon, Pa., Cleveland 6, Ohio, Indianapolis 6, Ind., Melrose Park, Ill., and Chicago 50, Ill.

NATIONAL MALLEABLE and STEEL CASTINGS COMPANY
CLEVELAND 6, OHIO

convertiplane (which starts and lands as a helicopter but flies as an airplane) is underway;

• High maintenance costs of helicopters, their powerplants and other components must be reduced by simpler design;

• The military is looking to industry to achieve simplification and lower manufacturing and maintenance costs.

Vice-Chairman D. Marshall Klein, who was applauded for planning the outstanding meeting, reminded the younger members that they were enjoying the privilege of living "in an era of pioneering and meeting one of its great pioneers, just as older SAE members had the experience of knowing the Wright brothers and saw those ideas put into actuality throughout the world."

Sikorsky repeatedly warned his audience that his opinions were his own and praised the work of designers whose ideas differed from his.

"Speeds of from 150 to 175 mph appear to be the limit for conventionally designed helicopters," he said. "Perhaps that is fast enough in view of the many vistas which are constantly being opened to helicopters."

A 100-ton useful load machine is now being studied. A 50 passenger machine could be built upon request, and Sikorsky envisioned power applied to the rotor by smaller props and the use of gas turbine powerplants for the helicopter of tomorrow.

Shale and Coal Possible Sources of Oil

• Washington Section
Lewis C. Kibbee, Field Editor

Jan. 15—**W. C. Schraeder**, assistant director, Bureau of Mines, addressed the Washington Section this evening. Schraeder's timely topic was synthetic fuels, and he addressed a large audience of interested people from the Nation's Capital.

Schraeder prefaced his remarks by saying that the demand for petroleum products at the present time runs about 7.5 million barrels per day. Our production may run nearly 1 million barrels lower than this figure. War or a national emergency would increase our needs very greatly and would cause acute problems. We are importing large amounts of oil from the Carribean and the Middle East. The demand for petroleum products is steadily increasing, and by 1965 we may require 10 to 12 million barrels per day. Though we are drilling 44,000 wells annually, the gap between our demand and production is still increasing. To meet the projected increase in demands for petroleum, new sources must constantly be developed. We may make up the gap between demand and supply by increased imports from the Middle East, the Carribean

MORAINE

an important producer of friction materials

Products using friction materials are big-volume business at Moraine. Custom-developed friction materials utilizing the powder-metallurgy process and/or other special semi-metallic or non-metallic facings are in active production.

Applications are broad: these materials are in standard use on automotive transmissions such as the Hydra-Matic, Powerglide and Dynaflow. These custom-made materials are also used in tank and truck automatic transmissions. The principles involved have many additional applications in the automotive and household appliance fields, and in the Army, Navy, Air Force and Ordnance materiel.

If your needs meet normal production methods here, and the quantity is sufficient to justify tooling costs, Moraine may be able to help you.

METAL POWDER PARTS BY MORAINE

MORAINE PRODUCTS
DIVISION OF GENERAL MOTORS • DAYTON, OHIO

Have you heard what Bagdad Copper Corporation is reporting on its Buda-powered Dart Trucks in which the power is put to work through the *new* Twin Disc DF Hydraulic Torque Converters?

"The trucks negotiate the steep grades fully loaded and *without ever shifting* gears . . ."

"They return down grade *without using the brakes* . . ."

"Total maintenance and repair costs may be *less than 2 cents per ton*...far less maintenance than ever before . . ."

"Fuel costs per ton of ore hauled with the torque converter have *decreased instead of increasing* as was presumed."

The Twin Disc Model DF is a three-stage hydraulic torque converter with built-in converter braking feature which not only eliminates gearshift guesswork on grades but also, combined with engine drag, can perform 90% or more of the braking. The records the DF is setting are amazing. Write today for details. You may be able to save hundreds of dollars per unit in maintenance savings and faster round trips.

TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin · HYDRAULIC DIVISION, Rockford, Illinois

BRANCHES: CLEVELAND · DALLAS · DETROIT · LOS ANGELES · NEWARK · NEW ORLEANS · SEATTLE · TULSA

area, or elsewhere. If we are cut off from foreign sources our production at home may be increased by (1) secondary recovery operations in existing oil fields, (2) conversion of oil shale, (3) production of oil from coal.

Touching on the latter two alternatives, Schraeder gave the following outline of prospects.

Oil Shale:

Oil production from shales has the advantage of being the cheapest way of obtaining oil except from petroleum, and has the additional advantage of being the simplest to develop. The average western oil shale contains about 30 gal of oil per ton of shale. Known reserves of shale oil amount to about 80 to 90 billion tons. The mining cost was originally very high. From 38 to 40 tons per man day was formerly considered good production. The Bureau of Mines has now developed methods characterized by the use of very heavy machinery, by which production has been raised to 148 tons per man day; the mining costs, including all men engaged in any part of the preparation, is about 47¢ per ton. The modern mining operation recovers about 96% of the oil theoretically present in shale. The fuel used in recovering the oil is furnished from the shale itself. A shale oil has an API gravity of about 20 (7.78 lb per gal). The gasoline yielded by normal production methods is about 45%. The octane number of clear unleaded gasoline from shale can be made about 75 to 80. An excellent diesel fuel can also be produced.

According to the Bureau of Mines analysis of production methods, gasoline can be produced from oil shale at prices to compete with petroleum, provided operations are on a large scale. Full scale production of shale oil, including a pipeline to the Pacific coast, can be financed for about $4,500 per barrel day as compared to about $6,000 to $8,000 for petroleum. An interesting sidelight of shale oil production is that there is in all probability less use of manpower than is required for a similar production using petroleum.

Using present refinery methods, it is possible to obtain about 55% of petroleum recovered as gasoline. The cost of shale oil gasoline at the refinery including a margin of profit is about 12¢ a gal, which is about the same as petroleum.

The development of a shale oil industry would make a great change in the economic picture in the western states, with the employment of thousands of men and the construction of whole new cities.

Gasoline From Coal:

The production of oil from coal depends essentially on the addition of hydrogen to the coal. Basic processes have been developed. One method depends on the Fischer-Tropsch process, basically the catalytic hydrogenation of carbon monoxide produced from the

hydrogenation by reduction by steam.

The octane number of gasoline produced from coal compares favorably with that produced from shale oil. A good grade of lubricating oil can be produced by the Fischer-Tropsch synthesis.

Bureau of Mines analysts believe that gasoline produced from coal on a large scale would sell at the refinery for about 18¢ per gal. However, the apparent high cost of production would be somewhat offset by the large amounts of valuable by-products, such as phenols, toluenes, benzene, and so forth. The Bureau experts believe that the expanding chemical industries could absorb the large amounts of these materials which would be produced from a large-scale production of gasoline from coal. If so, the process would also be able to compete economically with petroleum. Even though representatives of the petroleum industry do not agree with this analysis, our coal reserves are so large that an adequate supply of motor fuel is assured for as far into the future as we are now able to make reasonable predictions.

New Cars Designed For Style, Safety and Higher HP

• Washington Section

Lewis C. Kibbee, Field Editor

Feb. 19—**Joseph Geschelin,** Detroit editor of the Chilton publication "Automotive Industries," spoke before a standing room only audience as he discussed the 1952 passenger automobiles.

Ford, Mercury and Lincoln have entirely new body designs this year, Geschelin said. Another innovation is the Hydra-matic transmissions on Oldsmobile and Pontiac which embody new features. He pointed out that there was some tendency toward small cars this year, but indicated that their lack of popularity is primarily due to their being nearly as expensive as "full size" automobiles. Overhead valves and V-8's are the trend this year. Improvements directed towards style, safety and higher horsepower are the principal changes. One feature pointed out by Geschelin as a safety improvement was the low short hoods on the new cars which permit better visibility to the front of the vehicle.

The new Chrysler engine for 1952 was covered in some detail. The speaker pointed out the following features of this new 180 hp V-8 engine: (a) two rocker arm shafts, (b) water heated carburetor throttle, (c) hydraulic valve lifters, and (d) short rigid crankshaft. In discussing this engine, Geschelin said that the DeSoto engine is exactly the same type, but with a rating of 160 hp. He said that the compression ratio is 7.1:1 but that both engines use standard "house

Beat...
"BREAK-IN"
SERVICE COSTS
...before they start...
LISLE Magnetic
DRAIN PLUGS

You can prevent serious damage caused by abrasive metal particles which flake off moving parts and circulate in the lubricant of a transmission, crankcase, overdrive or rear axle.

A small investment in Lisle Plugs can save you hundreds of dollars in needless service costs during the critical guarantee period.

YOU *can try them free. Write for FREE Lisle Magnetic Plug for testing. Specify size and type desired.*

LISLE Corporation
CLARINDA, IOWA

even though you bought it for...

1¢

it may cost you over

12¢*

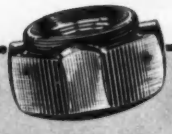
¢ 12¢

...in labor to assemble it into your product!

And when you use such fasteners by the thousands you can be adding TOO MUCH to your product costs.

Now you can use Midland Weld Nuts in assembling *your* product—wherever "Blind Spots" slow assembly operations, wherever you're using two men now to tighten a single bolted connection.

MIDLAND



WELD NUT

The MIDLAND STEEL PRODUCTS COMPANY

6660 Mt. Elliott Ave. · Detroit 11, Michigan

Export Department: 38 Pearl St., New York, N. Y.

MANUFACTURERS OF:

AUTOMOBILE AND TRUCK FRAMES

AIR AND VACUUM POWER BRAKES

AIR & ELECTRO-PNEUMATIC DOOR CONTROLS

brand" fuels as opposed to some of the newer engines which require premium fuels.

The new Willys-Overland sedan was the next vehicle reviewed. Its F-head engine is an adaptation of the standard 6-cylinder produced by Willys. This engine was the first to have valve rotators in the passenger car field, and is designed to run on regular fuel.

The new Lincoln engine with 317 cu in. displacement, 7.5:1 compression ratio, and 160 hp at 3900 rpm was the next engine discussed. This engine, like the Cadillac, is an overhead valve V-8 with a short rigid block. One interesting feature is that the center of the crankshaft is above the parting line of the crankcase, making a very shallow oil pan which is necessary to fit in a chassis with an extremely low silhouette as in the new Lincoln car. This engine incorporates a full flow oil filter, valve rotators on both intake and exhaust valves, and a Holley carburetor which is integrally designed with its air cleaner. This new air cleaner-carburetor design saves 4 in. in hood height. This feature is also incorporated in the new Mercury. The new Lincoln engine has an unusual feature in that no valve guide bushings are used. Ford Motor Co. engineers claim that this reduces valve temperature 125 F through better conduction when the valve runs directly in the head. It is interesting to note that this engine requires a premium fuel, and the speaker pointed out that many more selective fits are used in its manufacture.

The Ford 6-cylinder overhead valve engine, a newcomer this year, was said to be designed for 7 main bearings in the future, although at present production it will have only 5.

The Studebaker V-8 overhead valve engine, though much like some of the other V-8's recently adopted, has no hydraulic valve lifters.

In discussing some chassis features, the speaker touched on the new front-end design of the Lincoln, which incorporates ball-joint suspension, a relative newcomer in the front-end picture. Lincoln engineers claim this arrangement is so free from friction that no hydraulic steering mechanisms are offered on the car, even as optional equipment, as contrasted to the other new cars in this high price class.

The new Willys car has joined the integral frame family, and it is interesting to note that the front end suspension is built directly into the wheel housings.

The new Cadillac with its 190 hp engine now incorporates two exhaust lines, each with an expansion chamber and a muffler, and each terminating in a tail pipe built into the rear bumper. Cadillac offers two alternate rear axle ratios, and the dual range Hydra-matic.

DeSoto's four options of drive mechanisms were briefly touched upon, together with the options of rear axle ratios. Ford offers three drive systems and again multiple rear axle ratio choices.

What Do You Want Most in Tube Fittings?

NO LEAKS

ability to withstand VIBRATION

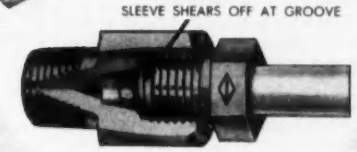
FASTER assembly

Get Them ALL in

IMPERIAL *Hi-Duty*® FITTINGS

The Tube Coupling that will not leak even under vibration

Imperial Hi-Duty Fittings withstand over 5 times as much vibration as ordinary Compression or Flared brass fittings. Design of sleeve minimizes deformation of tubing in assembly—tubing is kept stronger at points of greatest stress. Trouble-proof performance proved by widespread use in severe applications.



★ **For Tubing ⅛" to ¾" O.D.**

★ **Available in Brass or Aluminum**

★ **Ask for Bulletin No. 3002**

Easier and Quicker to Assemble

Fitting comes with nut assembled. To get a tight joint, simply insert tube into fitting and tighten nut. No loose sleeve to drop . . . no flaring required. Makes repeated tight reconnections.

With IMPERIAL you can be sure of the finest in fittings . . . fittings that have *forged* bodies on elbows and tees providing greater strength and toughness . . . *long* Dryseal pipe threads for extra assurance of tight pipe connections. See Catalog 350.

THE IMPERIAL BRASS MANUFACTURING COMPANY

1225 W. Harrison St., Chicago 7, Illinois

In Canada: 33 Church St., Toronto, Ontario

IMPERIAL

Pioneers in Tube Fittings and Tube Working Tools

AEROPHYSICISTS, DESIGNERS, ENGINEERS—

HERE'S AN EXCITING CHALLENGE

Aerophysics, Electro-Mechanics; Research, Design, Development, Test; The Finest Facilities, Equipment and Materials—all these maintain North American's reputation of keeping "ahead of the industry." You too can be a part of the "North American Challenge" to the future. Write today for information on career opportunities. Please include a summary of your education, background and experience.

Check These North American Extras—

Salaries commensurate with ability and experience • Paid vacations • A growing organization • Complete employee service program • Cost of living bonuses • Six paid holidays a year • Finest facilities and equipment • Excellent opportunities for advancement • Group insurance plan • Sick leave time off • Generous travel allowances • Employees Credit Union • Educational refund program • Low-cost group health, accident and life insurance • A company 24 years young.

IS YOUR FIELD LISTED HERE ?

Flight Test Instrumentation
Airborne Electronic Equipment
Equipment Flight Tests
Precision Instruments
Automatic Controls
Propulsion Systems
Servo-Mechanisms
Airframe Studies
Radar Devices
Instrumentation
Micro Wave Techniques

NORTH AMERICAN AVIATION, INC.

Aerophysics, Electro-Mechanical Research Division

Personnel Section, 12214 Lakewood Blvd. Downey, California

In summing up his discussion Geschelin stated that he felt that overhead valve V-8's would be the "standard" engine for passenger-car use in the future, barring unforseen production difficulties. Compression ratios are not extreme, probably due to the lack of proper fuel, and most engines have been designed to run on regular fuel with very few exceptions. Although speedometers read as high as 120, it is thought that few of the new cars will actually go much faster than previous models. The upping of horsepower in new vehicles has been aimed at increasing performance at speeds of 50 to 70 mph without giving greater top speeds.

Geschelin hinted at a possible innovation in the engine production field when he mentioned Alcoa's new technique of making cast aluminum engines to replace cast iron. Under their production processes, a single block could be fabricated from five separate castings which would be fused together in an oven. Should this process become widely available, the cost of producing V-8 engines would be substantially reduced. While on the subject of manufacturing techniques, Geschelin mentioned the advances made by the Ford Motor Co. with their shell-molding process used in the construction of engine crankshafts.

Following Geschelin's paper, a discussion from the floor covered the following points:

(1) Full flow oil filters: It was brought out that the Ford Motor Co. advocates longer periods between oil changes providing the oil filter cartridge is changed frequently.

(2) There was some discussion of the new chromium trim now being used on vehicles. The speaker noted that satisfactory performance of this nickel-free coating can be achieved provided proper care is given the finish.

(3) Some discussion of the two schools of thought on power steering followed the speaker's remarks that Gemmer gears were always using power regardless of steering effort required, while Saginaw gears used power only when wheel rim pull exceeded a given amount. It also developed that power steering adds approximately $200.00 to first cost.

(4) The speaker noted that the trend in the higher-priced engines was definitely to V-8's, but he felt that the overhead valve straight 6 would continue to be in the picture in the low-priced field for some time to come.

(5) Fuel injection was said to be a long way off because of production troubles and high cost.

(6) Engines in the rear are in the same category.

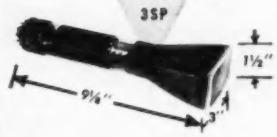
(7) Smaller car popularity is at a low ebb, due probably to their high cost despite lack of deluxe features.

Following the technical paper and its discussion, a film about the Indianapolis 500-Mile Race was shown, courtesy of the American Automobile Association.

THE RAYONIC®

CATHODE RAY TUBES

BY WATERMAN



Since the introduction of Waterman RAYONIC 3MP1 Tube for miniaturized Oscilloscopes, Waterman has developed a rectangular Tube for multi-trace oscilloscopy. Identified as the Waterman RAYONIC 3SP, it is available in P1, P2, P7 and P11 screen phosphors. The face of the Tube is 1 ½" x 3" and the over-all length is 9⅛". Its unique design permits two 3SP Tubes to occupy the same space as a single 3" round tube, a feature which is utilized in the S-15-A TWIN-TUBE POCKETSCOPE. On a standard 19" relay rack, it is possible to mount up to ten 3SP tubes with sufficient clearances for rack requirements. Thus 3SP RAYONIC tube is ideal for multi-trace oscilloscopic work.

Maximum 2nd anode voltage 2750 volts ... Satisfactory operation can be achieved at 600 volts ... Vertical deflection factor 52 to 70 volts DC per inch per kilovolt ... Horizontal deflection factor 73 to 99 volts DC per inch per kilovolt ... Grid cut-off voltage 2.8 to 6.7% of 2nd anode potential ... Focusing voltage 16.5 to 31% of 2nd anode voltage ... Heater 6.3V at .6 amp ... Twelve pin small shell duodecal base ... Tube can be mounted in any position ... 3SP1 JAN approved.

WATERMAN PRODUCTS CO., INC.

PHILADELPHIA 25, PA.

CABLE ADDRESS: POKETSCOPE

WATERMAN PRODUCTS INCLUDE:

3JP1 & 3JP7 JAN RAYONIC CR TUBES
3JP2 & 3JP11 RAYONIC CR TUBES
3MP7 & 3MP11 RAYONIC CR TUBES
3RP1, 2, 7, 11 RAYONIC CR TUBES

Also POCKETSCOPES, PULSESCOPES, RAKSCOPES and other equipment

WATERMAN PRODUCTS

BALL BUSHING

The BALL BEARING for your

LINEAR MOTIONS

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers have solved this problem by application of the Precision *Series A* or Low-Cost *Series B* BALL BUSHINGS.

Alert designers can now make tremendous improvements in their products by using BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

Improve your product. Up-date your design and performance with BALL BUSHINGS!

Now manufactured for ¼", ½", ¾", 1", 1½" and 2½" shaft diameters.

LOW FRICTION • LOW MAINTENANCE
ELIMINATES BINDING AND CHATTER
SOLVES SLIDING LUBRICATION PROBLEMS
LONG LIFE • LASTING ALIGNMENT

Write for descriptive literature and the name of our representative in your city.

Progressive Manufacturers Use Ball Bushings
— A Major Improvement at a Minor Cost

THOMSON INDUSTRIES, INC.

Dept. A MANHASSET, N.Y.

Also manufacturers of NYLINED Bearings — DuPont NYLON within a metal sleeve—for rotation and reciprocation.

New Members Qualified

These applicants qualified for admission to the Society between Feb. 10, 1952 and March 10, 1952. Grades of membership are: (M) Member; (A) Associate; (J) Junior; (SM) Service Member; (FM) Foreign Member.

Atlanta Group

P. W. Godard (M)

Baltimore Section

Donald G. Haser (J), Frank Martin, Jr. (M).

British Columbia Section

George Henry Eaton (A).

Buffalo Section

Jack C. Bassie (J), Albert H. Gille (A), Sherlock Andrews Herrick, Jr. (J).

Canadian Section

George William Burley (M).

Central Illinois Section

Lawrence F. Clancy (J), Frank S. Ferre (J), Lewis Frank Garnant (J), Richard H. Grosse (J), C. Richard Jefferson (J), S. Philip Nordling (M), Austin G. Skromme, Jr. (J), Charles L. Zuck, Jr. (J).

Chicago Section

Ralph F. Burns (M), James J. Duggan (J), Paul W. Ellis (A), Wilson A. Gebhardt (M), Allen H. Glasenapp (M), William Arthur Kolinger (J), Don J. Notary (J), Wilford Oscar Nystrom (J), Boleslaus F. Przybycin (J), Nikolaus V. Rucker (M), Daniel Milton Wade (J), Thomas Earl Williams, Jr. (J).

Cleveland Section

Harold E. Chassee (M), Albert C. Drechsler (M), Harvey E. Kennath (J), James E. Kennedy (A), Richard W. Lavin (J), George B. Longan (M), Robert L. Pence (J), Arthur L. Powell (A), John C. Purcell (M), Gustav A. Riss (M), William Warren Schafer (J), Rudy J. Zikesch (J).

Colorado Group

Capt. Kenneth W. Neudeck (SM).

Dayton Section

Thomas Albern Thompson (J).

Detroit Section

Richard E. Baker (J), Truman F. Barbier, Jr. (J), Richard Donald Blakley (J), Wilfred R. Boerner (J), Lloyd Leonard Bowden (A), H. O. Brakenberry (M), William C. Bubniak (J), Gerald S. Buerge (J), Jack L. Campau (J), Robert M. Carlson (J), Eugene E. Flanigan (J), Robert J. Grant (J), Jack Alden Green (A), Philip David Marriner (J), Albert N. Pedri (M), Gordon Wesley Phillips (J), John C. Pratt (J), Charles M. Scales III (J), Ralph P. Schmuckal

Continued on Page 131

The engineering department that consistently produces the "best" at the right time—B-25, F-51, T-6, now the F-86 *Sabre* jet series, AJ-1, FJ-1, FJ-2, T-28, B-45—offers engineers a real opportunity to become a part of the advance idea teams that are designing today for tomorrow and the future of aviation. Become a part of the outstanding aircraft engineering group in the aircraft industry by writing for complete information on career opportunities at North American. Please include a summary of your education, background and experience.

North American Extras—

Salaries commensurate with ability and experience • Paid vacations • A growing organization • Complete employee service program • Cost of living bonuses • Six paid holidays a year • Finest facilities and equipment • Excellent opportunities for advancement • Group insurance plan • Sick leave time off • Generous travel allowances • Employees Credit Union • Educational refund program • Low-cost group health, accident and life insurance • A company 24 years young.

CHECK THESE OPPORTUNITIES AT *North American*

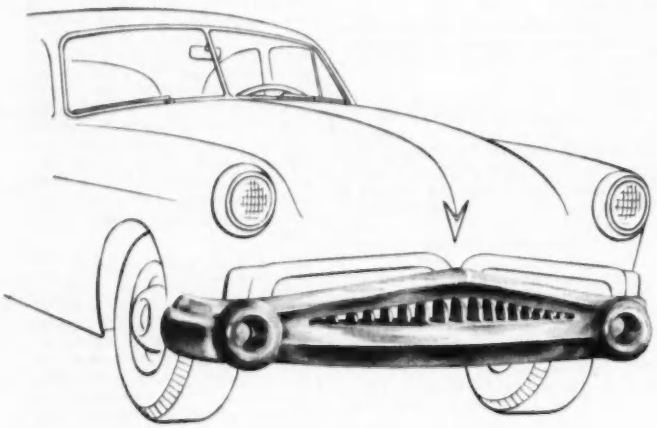
Aerodynamicists
Stress Engineers
Aircraft Designers and Draftsmen
Specialists in all fields of aircraft engineering
Recent engineering graduates
Engineers with skills adaptable to aircraft engineering

NORTH AMERICAN AVIATION, INC.

North American Has Built More Airplanes Than Any Other Company In The World

Engineering Personnel Office
Los Angeles International Airport
Los Angeles 45, Calif.; Columbus 16, Ohio

When you think of BUMPERS *



* think of

Standard Steel Spring Company

MAIN OFFICE: CORAOPOLIS, PA.

PLANTS: Allegan, Mich. · Gary, Ind. · Chelsea, Mich. Chicago, Ill. · Logansport, Ind. · Coraopolis, Pa. Newton Falls, Ohio · Detroit, Mich. · New Castle, Pa. Los Angeles, Calif. · Trenton, N. J.

DISTRICT OFFICES: 1600 Fisher Bldg., Detroit, Mich. 7035 West 65th St., Chicago, Ill.

RESEARCH LABORATORY: Coraopolis, Pa.

DIVISIONS *and their products*

BUMPERS
STANDARD STEEL SPRING CO.
Coraopolis, Pa.
Newton Falls, Ohio

UNIVERSAL JOINTS
BLOOD BROS. DIVISION
Allegan, Mich.

COIL, PRECISION AND MECHANICAL SPRINGS
MUELHAUSEN SPRING DIV.
Logansport, Ind.
CHELSEA SPRING DIV.
Chelsea, Mich.

OPEN STEEL FLOOR GRATING
STANDARD STEEL SPRING CO.
Gary, Ind.

CORRONIZING
STANDARD STEEL SPRING CO.
Coraopolis, Pa.

ARMOR PLATE
ARMOR PLATE DIV.
Detroit, Mich.

SEAT CUSHIONS, BACK SPRINGS
FALLS SPRING AND WIRE DIV.
Detroit, Mich.
GREAT LAKES SPRING DIV.
Chicago, Ill.
STANDARD STEEL SPRING CO.
Los Angeles, Calif.
Trenton, N. J.

FLAT LEAF SPRINGS
STANDARD STEEL SPRING CO.
Gary, Ind.
New Castle, Pa.

TUBULAR SEAT FRAMES
FALLS SPRING AND WIRE DIV.
Detroit, Mich.
GREAT LAKES SPRING DIV.
Chicago, Ill.

TUBULAR PRODUCTS
FALLS SPRING AND WIRE DIV.
Detroit, Mich.

New Members Qualified

Continued

(M), John E. Stewart (J), Edwin R. Stroh, Jr. (A), Gordon Fraser Taylor (J), Charles Joseph Weber (J), Ralph J. Wehrman (J).

Hawaii Section

Howard N. Mosher (A).

Indiana Section

Capt. Frank N. Price, Jr. (SM), Ronald D. Ramsey (J).

Kansas City Section

Delmont R. Peterson (M).

Metropolitan Section

David Hays Lachenbruch (J), William L. McAllister (M), Sheldon Rock (J).

Mid-Continent Section

John Howard Koch (M).

Mid-Michigan Section

Russell W. Durler, Sr. (M).

Milwaukee Section

Lawrence C. Fitch (J), Ralph W. Goetz (M), Keith J. Renish (J).

Mohawk-Hudson Group

William Carl Clas (J).

New England Section

Earl N. Comeau (J), Roland A. Girouard (A), Dr. Ross A. McFarland (M).

Northern California Section

Raymond E. Sickler (J).

Northwest Section

William Henry Davison (A), William L. Hubka (J), Glenn Eugene Rehn (J).

Oregon Section

William F. Le Fevre, Jr. (M), A. F. Olsen (M), Oren E. Ross (J), Carl G. Santesson (J).

Philadelphia Section

Bertrand L. Gulick, III (J), Clifford M. Welch (A), Stanley George Wlaz (M).

Pittsburgh Section

Alexander Lewis, Jr. (M).

St. Louis Section

Phillip J. Bergmann, Jr. (J), Albert G. Brinkmann (J), George E. Leutwiler (M).

San Diego Section

Robert Abercrombie Padgett (J), K. Stewart Peters (J), Hubert B. Starkey (J), James M. Van Vechten (M).

Southern California Section

John J. Bergwell (J), Bernard Guarneri (J), Herbert N. Johnson, Jr. (J), William Villeroy Moffat (M), John J. Udry (M).

Continued on Page 132

for exacting requirements

Pierce Production Facilities Can be Valuable to You

The Pierce-built precision instrument, shown above, regulates the flow of fuel to combustion chambers in America's finest turbojet aircraft engines.

It is a sensitive, compact, centrifugal-hydraulic control system with valve tolerances as close as 1/30,000th of an inch. Performance requirements demand flawless workmanship and quality control of the highest order.

Pierce facilities and experience are available to *you* . . . in the manufacture of high production small mechanical assemblies (machine work and assembly) . . . precision machining of mechanism castings . . . and fabrication of small stamped parts and assemblies.

Your inquiry will receive immediate attention. Write to Chief Production Engineer,

The PIERCE GOVERNOR CO., Inc. Box 1000, Anderson, Indiana

"WORLD'S MOST EXPERIENCED GOVERNOR MANUFACTURER"

New Members Qualified

Continued

Virginia Section

Bruce W. Cloninger (A).

Washington Section

Eugene I. Deas (J), George William Hampton (J), Lester M. Hoover (SM).

Western Michigan Section

Roy Wellington (J).

Williamsport Group

Paul Cervinsky (J), Carl A. Schwanbeck (J).

Outside Section Territory

J. W. Hanna (A), Thomas A. Hardwick (M), John G. Johnson (J), Clarence Kelly, Jr. (J), Capt. Paul Eugene Minuth (A), Ralph John Pecora, Jr. (J), Roy H. Spaulding (J).

Foreign

Wilfrid Metcalfe (FM), England; Debi Prasad Mukherji (FM), India.

Twice the Work of a Work Horse
Twice the Speed of a Race Horse
The Crosley FarmOroad "goes to town" plowing, harrowing, cultivating, mowing, raking and numerous other farm jobs — then carries the family and produce to town quickly, comfortably and economically. ROCKFORD CLUTCHES contribute to the sturdy dependability of this versatile unit. Let ROCKFORD clutch engineers help with your power transmission control problems.
ROCKFORD CLUTCH DIVISION
316 Catherine Street, Rockford, Illinois, U.S.A.
BW
B-W ENGINEERING MAKES IT WORK
B-W PRODUCTION MAKES IT AVAILABLE
ENGINEERING BULLETIN SENT ON REQUEST
ROCKFORD CLUTCHES

Applications Received

The applications for membership received between Feb. 10, 1952 and March 10, 1952 are listed below.

Atlanta Group

L. T. Daughtridge, Jr., Lester C. Malone.

Baltimore Section

H. Vaughn Lowther.

Buffalo Section

Harold I. Johnson, Daniel J. Kennedy, William Morrison Pitcher, John G. Vonhold, Jr.

Canadian Section

John F. Brooke, James P. Jolly, Ilmar Manner, Roger Rowland Watkins.

Central Illinois Section

Harry Bowen, Eugene Brookhouzen, Donald D. Henderer, Roy Thomas Paluska, Julian V. Sanders, James H. Taylor, Robert Irvan Wilson, Raymond Edward Holthe.

Chicago Section

Edgar H. Ayers, Christ P. Bozos, Richard S. Halladay, Clifford N. Hinkle, Joseph M. Husvar, Raymond C. McCullough, Paul C. Rathje, Stanley Z. Siwek, Roy W. Troxel, Jr., David W. Dawson.

Cincinnati Section

Raymond O. Hahn, Harry A. Truscott.

Cleveland Section

Clayton Ralph Chaminade, George D. Dolch, Jr., Otto H. Eberlein, John E. Ehlert, Lawrence L. Evert, Jr., R. Van Dyke Firth, Sr., Edward R. Fryer, Joseph R. Gensheimer, Edwin H. Horne, Everett Knapp, Frank C. Kreitler, Jr., Raymond H. Ptak, Marc Resek, Ernest C. Sweigert.

Dayton Section

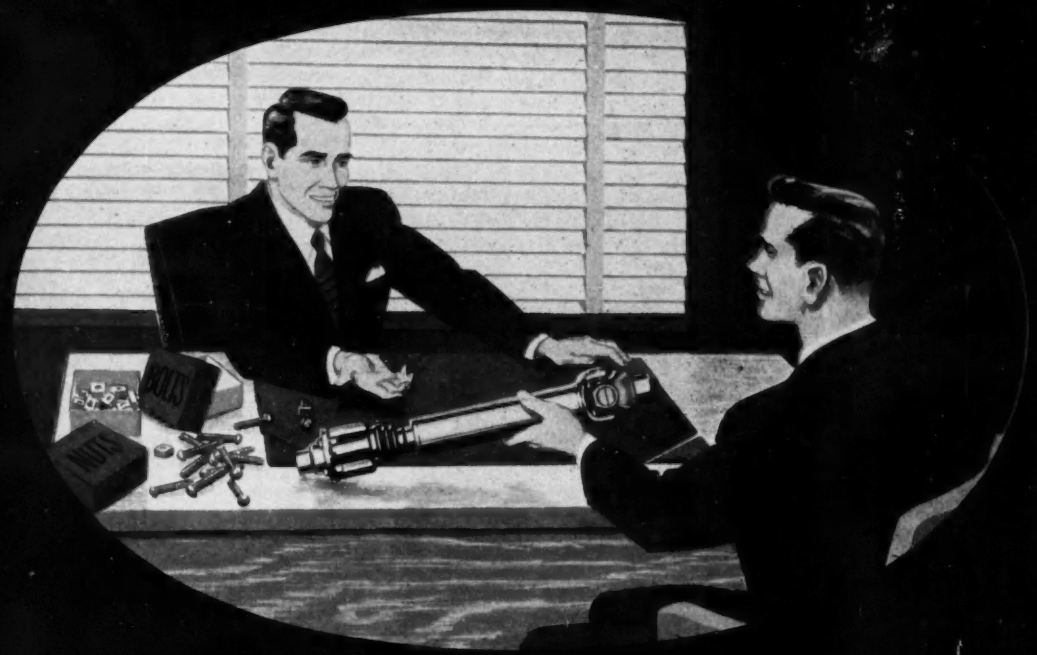
Charles E. Ryan, Jr.

Detroit Section

D. C. Apps, Bernhard R. Bermann, Arthur C. Blauwaert, Marvin J. Bloink, Donald Kendall Brooks, Robert L. Cave, Frank Louis Collar, David Edward Crockett, Roy Deming, C. Dwight Dilloway, Edward J. Dolan, William M.

Continued on Page 134

You Don't Buy Universal Joints Like Nuts and Bolts



Unless universal joints are designed for specific power transmission requirements, vehicle performance and the service life of the driveshaft are penalized. "DETROIT" Universal Joints are precisely engineered to deliver maximum torque smoothly to the rear wheels, yet provide thousands of miles of trouble-free service.

Detroit UNIVERSAL JOINTS

UNIVERSAL PRODUCTS COMPANY, Inc., Dearborn, Michigan

Applications Received

Continued

Fairhurst, Albert E. Feliska, J. Earl Fraser, David Y. Gardiner, E. E. Goepfrich, Kenneth W. Gordon, Norris L. Haight, George E. Herrman, Laurence M. Howarth, Virgil L. Iles, Robert E. Kidder, Richard E. Krafve, Clarence R. Krisher, Harold C. Leiphart, Alan Carlyle Lewis, Ray L. List, Lyman M. Miller, Marshall Edward Munroe, Jr., Edward L. Nash, William Ernest Oliver, Jack W. Palmer, Phillip George Plevek, Robert J. Pocock, Richard Owen Rauff, Robert Earl Ringe, Loyal J. Rodgers, Richard Vaughan Rogers, John R. Rubner, Franklin A. Sawyer, Mathew H. Schumer, Arthur H. Smith, Paul P. Thomas, Albert A. Thornbrough, Leon J. Verhaeghe, Kurt W. von Gruben, Paul W. Winkelmann, Clifford C. Wrigley, Arthur Aloysius Zakens, Earl Ziegler, Bernard Lynch Metsker.

Hawaii Section

Manning C. Allee, Eugene Richard Fitch, James Gonzales, Roger William Hume, A. C. William Ireton, Hamilton Agnew Mather, Jr.

Indiana Section

David C. Wynn.

Kansas City Section

Frank J. Danzo, William Henry Harper, S. L. Higginbottom.

Metropolitan Section

Albert H. Beaufrere, William G. Beiswinger, Michael Cutler, John Gerard Donovan, Robert Joseph Fabian, William D. Kent, Charles R. Limbacher, Joseph A. LiPuma, James Miller, James Thomas Mowles, Sidney B. Schulman, Frank P. Suk, Eugene Williamson, Ernest Victor Wilson, Antonio Compare.

Mid-Continent Section

Billy Ray Archer, Marion L. Ball, William H. Little.

Mid-Michigan Section

Arthur Huntingdon Elbers, Harold F. Schattenberg.

Milwaukee Section

Arthur G. Brown, Clarence Line Flessate, Quinten A. Hansen, Douglas E. Holt, John W. Lendved, Thomas B. Wakeland, Edward J. Reinelt.

Montreal Section

Gaston Beauchamp, Paul Etienne Blier, Maurice J. Bourgault, Abraham Esar, Gordon R. McGregor, Frank Potts.

New England Section

Vincent Carroccia, Alwin Edward Hodson, Jr., Jost A. Matzdorff, Maurice H. Weiner.

Northern California Section

Jack Arnold Bert, Granvil E. Crawford, Fred H. Dodson, Edgar F. Giesselmann, Robert J. Matthews, Harold D. Otto.

Oregon Section

Don M. McGuire.

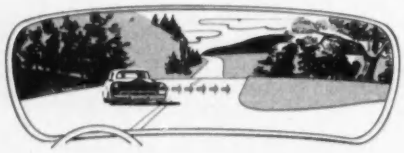
Philadelphia Section

Forrest Benton Arnold, Joseph R.

Continued on Page 136

3 TIMES SAFER

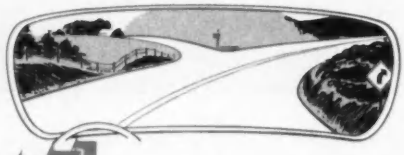
Tung-Sol Signal Flashers permit a three-way flashing hook-up for automobile or truck direction signals.



1 Warns the car approaching

2 Warns the car following

3 Instrument panel pilot light reassures the driver



More than 13,000,000 have been used. Most of them outlast the cars they're on.

TUNG-SOL®
SIGNAL FLASHERS
Dependable!

Tung-Sol makes All-Glass Sealed Beam Lamps; Miniature Lamps; Signal Flashers; Cathode Ray, Radio, TV and Special Purpose Electron Tubes.

TUNG-SOL ELECTRIC INC., Newark 4, N. J. Sales Offices: Atlanta • Chicago Culver City (Calif.) • Dallas • Denver • Detroit • Newark • Philadelphia

CONCRETE MIXERS *lead a double life!*

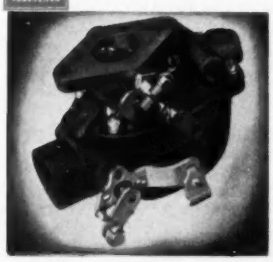
WHAT *we* learned about the double life of truck concrete mixers enables us to help engine manufacturers a lot when it comes to properly designing and calibrating carbureters.

One of our field service men brought us this story. After three or four days' normal operation, the exhaust of the concrete mixer engine gave off heavy black smoke. Changing the idle mixture ratio corrected the trouble temporarily. The cause was a double life!—long periods of low-speed, light-load operation, and very short periods of peak load. The result was rapid gumming and carbonization of the idle system.

The engine had the wrong carbureter—one designed for steady loads at high speed! To correct the trouble, we recommended a new idle system. Now, the engine manufacturer reports that test units operated six months during the peak season required no adjustment.

Over the years, Marvel-Schebler has accumulated a wealth of experience in carbureter applications for industrial engines. This experience is invaluable to Marvel-Schebler customers. If *your* engines are used in diversified markets requiring versatile carbureter performance, bring us your problems.

MARVEL-SCHEBLER PRODUCTS DIV.
Borg-Warner Corp., Decatur, Ill.



MARVEL-SCHEBLER
CARBURETERS

The SOFT Acting Clutch with the SURE GRIP!
. . . just like a Hand of Steel in a Velvet Glove
LIPE
MULTI-LEVER
CLUTCH
Lipe's soft-engagement, positive-grip Multi-Lever Clutch never needs babying. It engages smoothly—without grab, shock or jerk. All parts of the pressure plate touch at the *same instant* with the *same* pressure. There's no cocking—no point of high slippage and spot burning. Result: *More mileage between teardowns.*
The hand of steel in the Lipe Clutch has 20 fingers that equalize the pressure of a single spring—assuring softer engagement and a positive grip.
Lipe-ROLLWAY CORPORATION
Manufacturers of Automotive Clutches and Machine Tools
Syracuse 1, N. Y.

Applications Received

Continued

Clanan, George J. Elser, Karl F. Green, Leonard Francis Leone, A. E. Prichard, John R. Smyth.

San Diego Section

G. Fred Anderson, Jr., Robert Ashley.

St. Louis Section

Robert William Boehlow, Robert F. Bopp, Bobby D. Collison, Stanley T. Dueker, Robert E. Kennel, Jack M. White.

Salt Lake Group

Raymond G. Gann.

Southern California Section

Norman H. Dickman, Walter L. Fontaine, Eugene C. Kimball, Dudley J. Shrimpton.

Southern New England Section

Edmund Hoskins Case, Henry Clifford Morton, Edgar C. Shoup, Jr., Lawrence C. Simonette.

Spokane-Intermountain Section

Lewis J. McBride.

Texas Section

William Gross McMurry.

Twin City Section

Henry G. Halgren, Jack E. Leicher, Eugene P. O'Connor.

Virginia Section

Henry Walter McAllister, Robert E. Porter.

Washington Section

Charles B. Hanssen, Roy E. Jorgensen.

Western Michigan Section

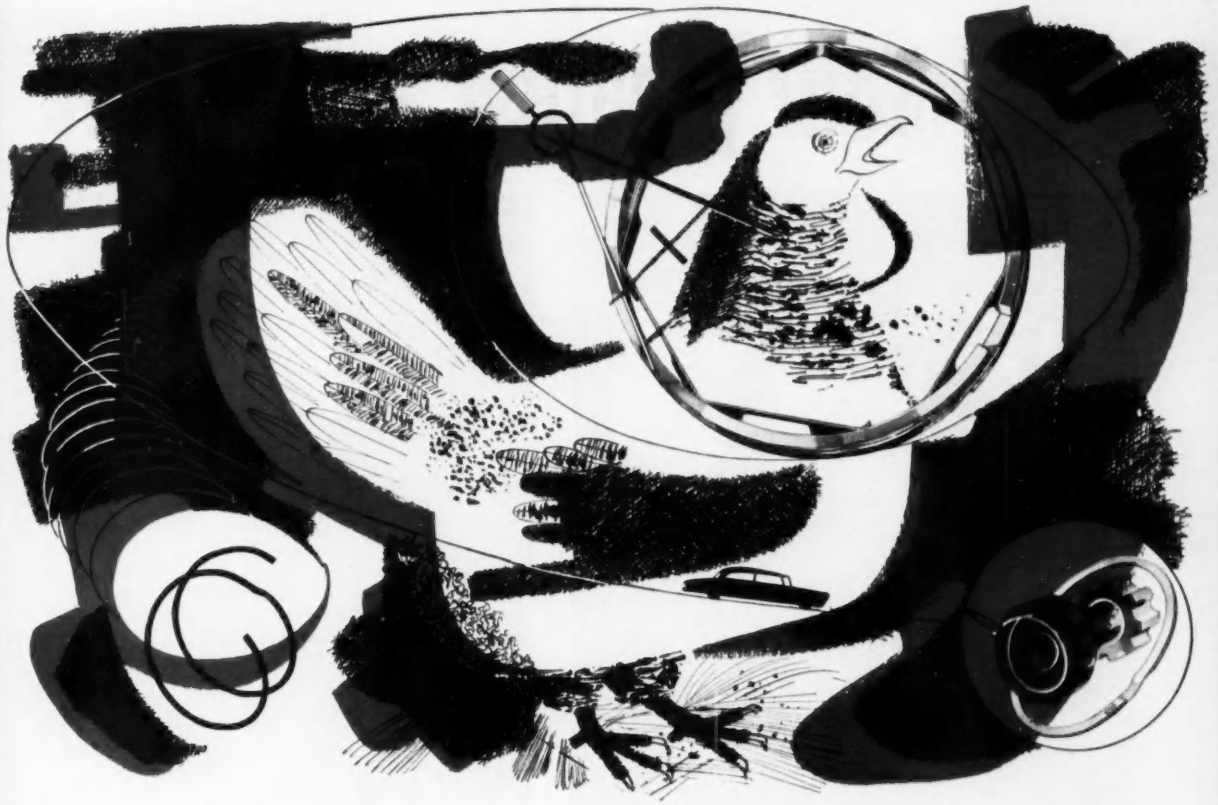
Gay Woods Duvall, Erwin W. Knoth.

Outside of Section Territory

James Colburn Addison, William Lawrence Denniston, Houston N. Irvine, C. S. Lagergren, DeAlton Martin.

Foreign

Pierre Auvray, Belgium; Narsinhbhai Kalyandas Patel, England; Ivan Arthur Morris, England; Henry R. Perkins, British West Indies; Donald G. Rawden, Australia; Sergio Vittorelli, Italy, Thomas Anthony Campobasso, Germany.



You can thank RAMSEY ENGINEERING

for making 'egg-shaped' holes serve as ROUND ONES... in car engines!

All America profits from an industrial "success story" in mass production.

This story began 30 years ago. It all started because of the surprising fact that in those days when the round cylinders in a car engine began to wear, they wore egg shaped.

Ramsey met that need with the Ramco Spring Inner-Ring. It did the job. Egg-shaped cylinder holes could be made to function almost like new, *inexpensively!*

A need was answered. Mass production at Ramsey began. Today, the demand for Ramco Piston Rings, embodying the Ramco Spring Inner-Ring—as well as for the many allied Ramsey Products for industrial and car factory use—calls for mass production by the tens of millions each year from 5 Ramsey manufacturing plants.

These mass production economies have enabled Ramsey Engineering to constantly invest time and money in the development of new, special, patented machinery. This exclusive Ramsey machinery not only produces rings faster and at lower cost...but also with *extra precision.*

That is why you can thank Ramsey Engineering for making egg-shaped holes serve as round ones. The resulting mass production is being reflected, year after year, in ever-higher precision standards for every product manufactured by the Ramsey Corporation.

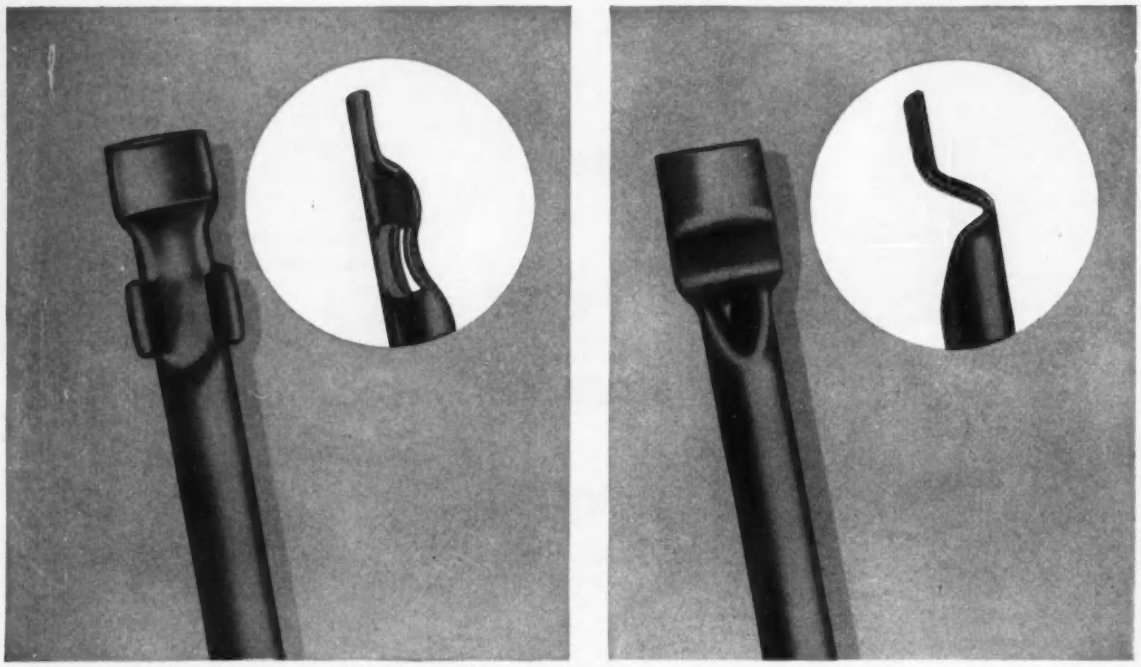
Makers of Ramco 10-Up Piston Rings, Ramco Inner-Rings, Ramco Piston Skirt Stabilizers. Seal-Tite and Oil-Tyte Piston Rings, **Spirolox Retaining Rings,** Spiro-Seal Grease Seals and Dust Seals, and special rings for Automotive and Industrial Application. **Factories:** St. Louis and Sullivan, Mo., Fruitport, Mich.; Toronto, Canada. **Ramsey Corporation,** General Offices: St. Louis 8, Missouri, a Subsidiary of Thompson Products, Inc.

Ramsey Corporation
PISTON RINGS
RETAINING RINGS

SETTING NEW AND HIGHER STANDARDS FOR HARNESSING ENERGY TO MAKE ENGINES AND MACHINES BETTER SERVE AMERICA

G-5844

Your greatest automotive



1. DESIGN SAVINGS

Doing everything possible to meet original customer specifications is a Bundy *must*. Yet Bundy engineers can often point out design improvements and fabrication savings. Above: vent tube, as specified, for use inside gasoline filler tube. Problem was to remove possibility of gasoline entering two side vents as gas tank was filled.

Above: Improved design suggested by Bundy engineers completely protects vent from gasoline entry by baffle deflection. More, this part requires just two operations: one to flatten end and pierce tube simultaneously, one to put double bend in flattened end. For customer, new design meant better function at lower part cost.

Bundyweld® Tubing

DOUBLE-WALLED FROM A SINGLE STRIP

WHY BUNDYWELD IS BETTER TUBING

Bundyweld starts as a single strip of copper-coated steel. Then it's . . .

continuously rolled twice around laterally into a tube of uniform thickness, and

passed through a furnace. Copper coating fuses with steel. Presto . . .

Bundyweld, double-walled and brazed through 360° of wall contact.

← **NOTE** the exclusive patented Bundyweld beveled edges, which afford a smoother joint, absence of bead and less chance for any leakage.

Bundy Tubing Distributors and Representatives: Cambridge, 42, Mass.: Austin-Hastings Co., Inc., 226 Binney St. • **Chattanooga 2, Tenn.:** Peirson-Deakins Co., 823-824 Chattanooga Bank Bldg. • **Chicago 22, Ill.:** Lapham-Hickey Co., 3333 W. 47th Place • **Elizabeth, New Jersey:** A. B. Murray Co., Inc., Post Office Box 476 • **Philadelphia 3, Penn.:** Rutan & Co., 1717 Sansom St. • **San Francisco 10, Calif.:** Pacific Metals Co., Ltd., 3100 19th St. • **Seattle 4, Wash.:** Eagle Metals Co., 4755 First Ave. South **Toronto 5, Ontario, Canada:** Alloy Metal Sales, Ltd., 881 Bay St. • **Bundyweld nickel and Monel tubing is sold by distributors of nickel and nickel alloys in principal cities.**

tubing buy on every count

You buy unmatched tubing features, priceless safe performance, *plus* cost-paring engineering skills when you specify Bundyweld Tubing.

You get *more* for your tubing dollar when you specify Bundyweld for automotive fuel lines, oil lines, hydraulic brake lines.

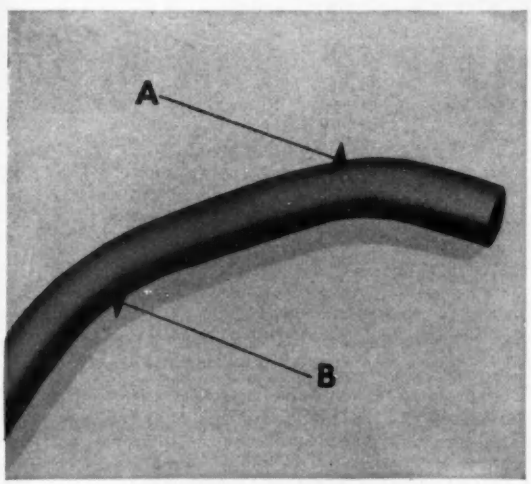
You buy unequalled tubing features. Bundyweld is the only tubing double-walled from a single strip, copper-brazed through 360° of wall contact. It's leakproof, highly resistant to vibration fatigue, lightweight, yet stronger.

You buy tubing performance that has made Bundyweld a byword for safety and dependability, proved by the 360,000 miles of Bundyweld used in cars, trucks and buses since 1930.

More, you buy the industry's finest skills and services. Bundy engineers help you work out the easiest, most economical way to produce new tubing parts; often save money by showing you how to use less tubing, how to make production short cuts. If you wish, Bundy will take over complete fabrication of your tubing parts — produce them as specified, deliver them on time.

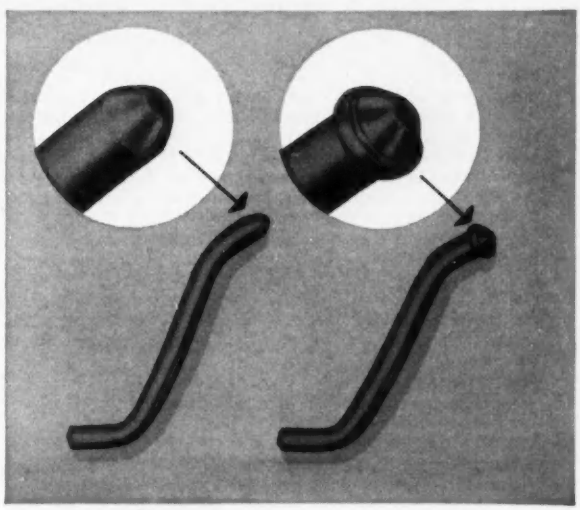
Whether you prize safe performance or cost-cutting engineering skills, specify Bundyweld . . . and you'll buy both.

Contact a Bundyweld Distributor (listed lower left), or write direct to *Bundy Tubing Company, Detroit 14, Michigan*



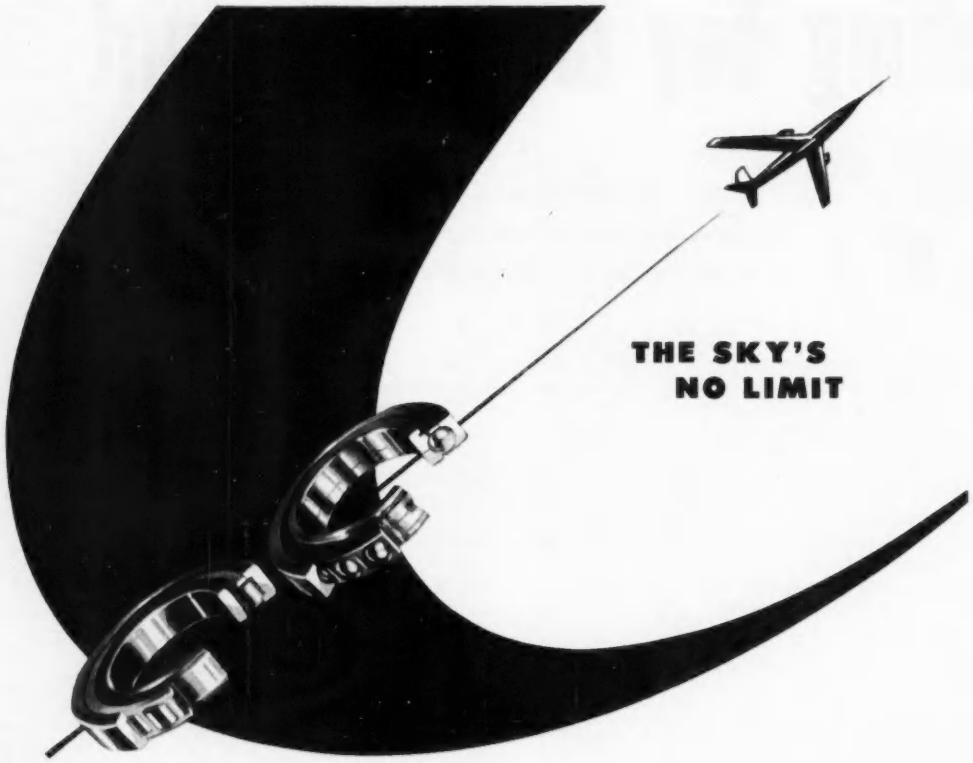
2. COST SAVINGS

Bundy engineers are always on the lookout for new ways to shave costs. For example, the 7/16"-O.D. oil tube shown above required two bends, yet both ends had to be held to exact size. The nearness of Bend A to the end of the part made holding of exact size difficult. Bundy engineers went right to work on the problem, came up with *results*: bending and sizing were combined in one press operation for high-volume production, lowered costs. Specify Bundyweld and you tap engineering skills dedicated to paring costs, whether you fabricate tubing parts or Bundy fabricates them for you.



3. FABRICATION SAVINGS

The 3/16"-O.D. timing-gear oiler tube shown above required tapered end for a nozzle effect. As specified by customer (left), it required numerous swaging operations. With customer's consent, Bundy added upset to nozzle tip (right). As a result, nozzle-forming operations were cut in half. But Bundy bird-dogging didn't stop there. Two hand-bending operations were incorporated into one automatic press operation. The over-all result: impressive fabrication savings to the customer, with no compromise in tubing function.



"Give me a place to stand and I'll move the earth." Archimedes meant, with a place to stand in the sky, he could pry the earth from its orbit. In Archimedes' day, the sky was the limit — but no more.

Men go farther and faster now than ever before, the sky's no limit, because progressive SKF bearing design coupled with proven manufacturing know-how assures reliable engine performance in today's rugged aircraft.

SKF intends to continue its four decades of close cooperation with the aviation industry, pioneering aviation's needs for new and improved bearing designs.

And will continue to provide every industry with eight good reasons for preferring SKF: Integrity, Craftsmanship, Metallurgy, Tolerance Control, Surface Finish, Product Uniformity, Engineering Service, Field Service. 7309

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.—
manufacturers of **SKF** *and* HESS-BRIGHT *bearings.*

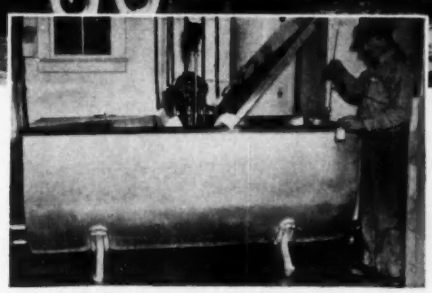
Anticipating aviation's demand for advanced bearing design— SKF is adding a wing to its Philadelphia Research Laboratory that will double its research facilities.

SKF®
BALL AND ROLLER BEARINGS

IN EVERY INDUSTRY, SKF Puts The Right Bearing In The Right Place

THIS TRUCK'S 3500 GALLON TANK (insulated) carries bulk milk from farm to city dairy. To maintain purity of contents... and for permanence... it is made from chromium-nickel stainless steel.

AT THE FARM... new milk moves via stainless steel milk lines or buckets into a stainless steel self-refrigerating tank, as shown below, where an agitator mixes it with milk cooled during the previous night. Contents of milkhouse tank are pumped directly into tank truck, and sped to dairy.



STAINLESS PLAYS IMPORTANT ROLE IN NEW SYSTEM

Of Direct Farm-To-Processor Bulk Handling of Milk!

"Something *new* has been added" to the six billion dollar milk industry...

A *new system*... in which chromium-nickel stainless steel contributes to quicker handling, less drudgery, better cooling, and above all, to higher and more uniform quality of product. Simplicity of the system is shown by the illustrations.

Appreciating its many advantages, United States Steel Company, a leading producer of stainless steels, has supplied these corrosion-resisting metals to many fabricators of milk tank trucks, farm bulk milk tanks and allied equipment.

Austenitic chromium-nickel stainless steels are highly resistant to food acids and atmosphere, as well as to most organic and a great many inorganic chemicals. The mechanical properties of stainless steels permit cutting bulk and deadweight without sacrificing strength or durability. Another all-important advantage is that they are easy to clean, and to keep clean.

Leading steel companies produce austenitic chromium-nickel stainless steels in all commercial forms. A list of sources of supply will be furnished on request.

At the present time, the bulk of the nickel produced is being diverted to defense. Through application to the appropriate authorities, austenitic stainless steels are obtainable for many end uses in defense and defense supporting industries. Counsel and data on alloys containing nickel, for your present production or future projects, are yours for the asking. We invite your inquiries.

INCO

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

Cylinder bore wear REDUCED . . 84.6%

Main bearing wear REDUCED . . 77.9%

Rod bearing wear REDUCED . . . 93.3%

Piston wear REDUCED 78.4%

with

PUROLATOR

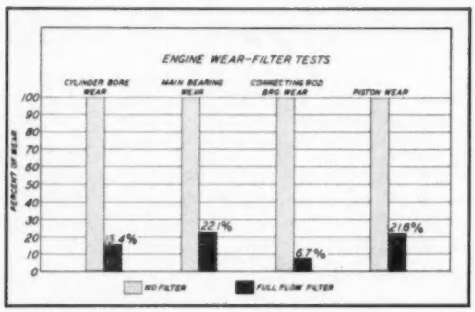
FULL-FLOW

MICRONIC FILTERS

THESE ARE THE RESULTS of tests just completed by one of the world's largest automobile and engine manufacturers.

The purpose of these tests was to determine how much the Micronic Full-Flow element reduces wear.

Running standard gasoline engines under extremely adverse conditions, test engineers found that Purolator Micronic* Full-Flow filtration was the best of all tried . . . far superior to any partial-flow filter.



The secret of this amazing performance is the Purolator* *Micronic* Filter Element with *ten times* the filtering area of old-style filters. It is the *only* element capable of delivering full-flow rates during its entire service life, with effective, dependable filtration down to *microns* (0.000039 in.)!

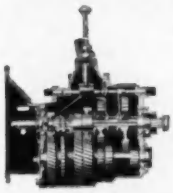
Purolator's Engineering Department will gladly cooperate in helping you adapt super-efficient Purolator Micronic Full-Flow filtration to your own requirements. *Just write!*

*Reg. U. S. Pat. Off.

PUROLATOR PRODUCTS, INC.
Rahway, New Jersey and Toronto, Ontario, Canada
Factory Branch Offices:
Chicago, Detroit, Los Angeles

PUROLATOR
MICRONIC OIL FILTER
"FIRST IN THE FIELD OF FILTERING"

Model 5-A-620 — one of 108 available standard Fuller Heavy-Duty Transmissions and Auxiliaries.



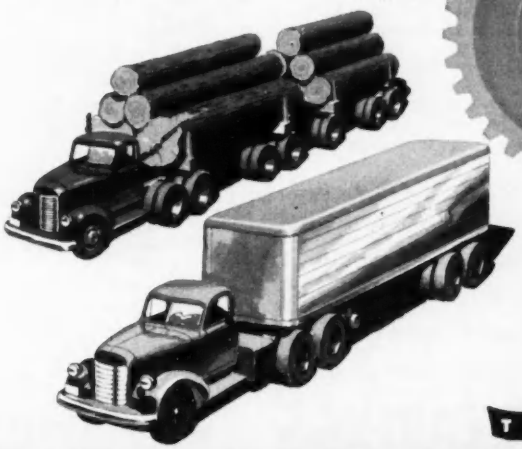
with enough gears, you can move the world

Iron ore from the Mesabi range . . . copper from the mines of Arizona . . . salt from the flats of Utah . . . coal from the pits of Pennsylvania . . . fruit and vegetables from California and Florida . . . big logs from the nation's forests . . . freight from coast to coast . . . the world's greatest transportation system constantly passes before our eyes . . . the world's most efficient trucks move over the marvels of economic history . . . the highways of America.

Leading designers, manufacturers, and operators of heavy duty trucks have worked closely with the Fuller Manufacturing Company from the very beginning of this transportation miracle—helping perfect and refine more efficient, longer lived and heavy capacity transmissions to assure every truck operator exactly the right gear ratios for his particular road and load conditions.

"Fuller Firsts" reflect this front-running teamwork . . . Fuller *first* to perfect a trouble-free transmission for high speed diesels; first to offer a line of auxiliaries so complete that *any* requirement could be met; first to harness up to 400 hp. in a single unit transmission; first with the revolutionary ROAD RANGER® with all ten speeds shifted by *one* lever—and no gear splitting.

Get the right gear to move *your* part of the world; the Fuller line is described in the *New* Condensed Specification Folder. Ask for it.



Fuller TRANSMISSIONS®

FULLER MANUFACTURING COMPANY (Transmission Division), KALAMAZOO 13F, MICHIGAN

Unit Drop Forge Division, Milwaukee 1, Wis. • WESTERN DISTRICT OFFICE (SALES & SERVICE—BOTH DIVISIONS), 1060 E. 11th Street, Oakland 6, Calif.

If JOHNSON Ledaloyl SELF-LUBRICATING BEARINGS WILL DO THE JOB

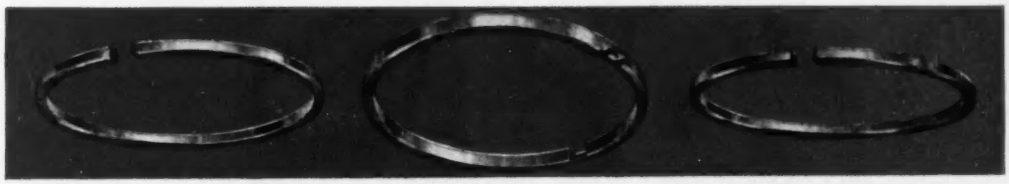
WHY SPEND MORE?

They are extremely low in cost because Ledaloyl bearings and parts are produced by powder metallurgy, molded to shape, and require no machining. Of course, they are suitable in only certain applications. But in these particular uses Ledaloyl bearings give the utmost in service. Many engineers have investigated —some have found uses and are now making substantial cost savings. Johnson engineers will be glad to help you determine whether you can use Ledaloyl bearings to your advantage. Write, wire or call now.

JOHNSON BRONZE CO., 675 So. Mill St., New Castle, Pa.

SLEEVE BEARING HEADQUARTERS SINCE 1901

JOHNSON JB BEARINGS
Sleeve-Type



Koppers K-Spun Rings

Manufactured in diameters up to 12½" by Koppers exclusive centrifugal casting process. 100% stronger, 4 times more resistant to combustion shock than ordinary rings. Will not break in installation or for the life of the engine. For high-speed diesels and other applications where extreme strength is needed.

Koppers Lug Seal Rings

A specially designed two-piece ring for use on badly out-of-round and tapered cylinders, or on pistons with worn grooves. Maintains compression at a high level, prevents blow-by, provides highly efficient oil control.

Koppers Porous Chrome* Rings

Porous Chrome surface holds and distributes oil during break-in, quickly wears to perfect seating. Combined with K-Spun metal in sizes up to 12½" dia. Last up to 4 times as long as other rings, cut cylinder wear up to 50%. Designed for top compression rings of high-speed engines.

** Van der Horst Process*

Here's why Koppers offers you piston rings in every size, of every type, for every purpose

Koppers Seal Rings

Specially designed ring with a projecting bronze band that causes a burnishing action on cylinder walls. Decreases scuffing and wear on cylinder walls of gas and diesel engines, air and refrigeration compressors and many other applications.

Koppers Step-Seal Rings

Designed especially for applications where blow-by is a serious problem. Combines the strength of a single-piece ring with the sealing qualities of a multiple-piece ring. For use on hydraulic presses and diesel and other internal combustion engines.

Koppers Oil-Cutter Rings

Exceptional oil control is attained by unique design . . . 2 bevels for riding over oil on upstroke, 2 scraping edges for taking excess oil from cylinder walls on downstroke, plus a series of wide drainage slots. For use on high-speed, 4-cycle engines.

These are a few of the hundreds of rings manufactured by Koppers.

EVERY piece of equipment presents a different piston ring problem. Koppers, with its wide variety of rings for every conceivable use, provides the solution to *all* industrial and automotive ring problems.

Our engineers, who work with you in determining the best rings for your applications, have all the facilities of the large, modern Koppers piston ring plant at their disposal . . . to supply you with the rings that will cut down-time, increase efficiency and lengthen the life of your equipment.

No matter what kind of equipment you have . . . railroad, stationary or marine diesels, aircraft or automotive engines, pumps, compressors, steam hammers, hydraulic presses . . . if it uses piston rings or sealing rings, write, wire or phone us today for experienced help with your piston ring problems. Koppers Company, Inc., Piston Ring Dept., 1524 Hamburg St., Baltimore 3, Maryland.

KOPPERS®

KOPPERS *Only KOPPERS can furnish K-Spun or Porous Chrome!*

AMERICAN HAMMERED **PISTON RINGS**

STOP

WASTING TECHNICAL TALENT

Turn over your special fastening problems to *specialists* . . . trained fastener engineers who have been through the trial-and-error stage in this highly specialized field and can free your own engineering staff for finished-product engineering.

It pays. We've proved it . . . for leading manufacturers in the automotive industry . . . and in the electronics, aviation, appliance and furniture industries, too.

United-Carr and its subsidiaries have had years of experience in the design and production of *tailor-made* fasteners and allied devices. Each division of the company provides a reservoir of special knowledge for the others. The result: an integrated organization that makes use of every improvement in materials and methods to produce fasteners that *speed assembly, cut costs* and, in many cases, actually *improve product performance.*

With complete facilities in our own plants for the volume production of special metal stampings and for the assembly of metal to plastic and ceramic components, we are in a position to supply practically any fastening need.

Before bidding on government contracts requiring fasteners or special fastening devices, consult your nearest United-Carr field representative.

UNITED-CARR

MAKERS OF DOT FASTENERS

UNITED-CARR FASTENER CORPORATION, CAMBRIDGE 42, MASSACHUSETTS

Get the RIGHT AXLE for YOUR job!

Go Modern with

TIMKEN Detroit AXLES

A PRODUCT OF THE TIMKEN-DETROIT AXLE COMPANY

DETROIT 32, MICHIGAN

The Accepted D A Co Standard

TRADE MARK REGISTERED

Here's One More Reason Why!

a complete "family" of advanced-related design front and rear axles.

Be sure you get exactly the *right* axle for *every* trucking job! Specify Timken-Detroit Front and Rear Axles on your new trucks and get the axle capacity and final drive that is exactly suited to the job to be done.

In rear axles, Timken-Detroit's "3 for 1" line includes several basic axle capacities to cover the entire field of medium and heavy-duty trucking requirements. These rugged axles have the same features of construction, the same interchangeability of parts, and the same outstanding performance characteristics throughout the entire range of sizes. They differ only in load-carrying, torque-transmitting and braking capacity. This complete line, with optional types of final drives and optional gear ratios available in each capacity, provides the most complete flexibility ever achieved in truck axle manufacture and use. In addition, a complete series of companion front axles are built by Timken-Detroit incorporating new advanced features for greater stability and safety.

The next time you buy trucks *go modern* with Timken-Detroit Front and Rear Axles and Brakes!

WORLD'S LARGEST MANUFACTURER OF AXLES FOR TRUCKS, BUSES AND TRAILERS

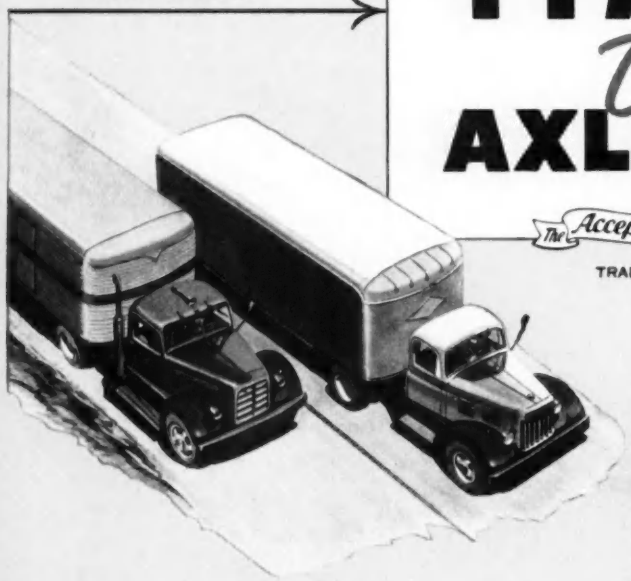
PLANTS AT: Detroit and Jackson, Mich. • Oshkosh, Wis. • Utica, N. Y. • Ashtabula, Kenton and Newark, Ohio • New Castle, Pa.

BEST for the first haul!
BEST for the thousandth!

LOOK FOR THIS SIGN!

Genuine TIMKEN Detroit AXLE PARTS

The Accepted D A Standard
TRADE MARK REGISTERED



Every Timken-Detroit Axle on your trucks was designed and engineered as a *unit!* That's why it's so important to replace worn parts with new ones that are specifically built to keep your axles in peak operating condition. Install only *genuine* Timken-Detroit Axle replacement parts.

These dependable parts are identical in every respect with the original parts in your Timken-Detroit Axles. They are made in the same Timken-Detroit plants to the same exacting specifications. They take less time to install, require no extra adjustments. What's more, many of these parts are packaged in protective kits containing *all* the essential related parts to do a factory-type replacement job.

Whenever you need parts for your Timken-Detroit-equipped trucks, look for the sign that reads "Genuine Timken-Detroit Axle Parts." You'll save money, time and trouble!

MAIL THIS COUPON FOR FREE ILLUSTRATED LITERATURE

The Timken-Detroit Axle Company
100 Clark Street, Detroit 32, Michigan

Gentlemen: Please send me free literature on Timken-Detroit Axle Parts.

NAME _____

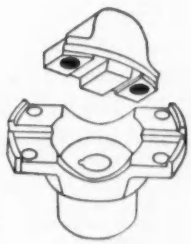
ADDRESS _____

CITY _____ STATE _____

I operate _____ (Number of trucks)

if VIBRATION is your problem

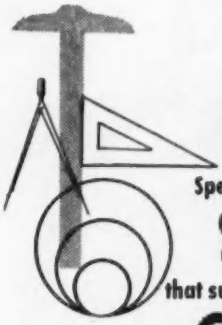
EVERY high Speed MECHANICS Roller Bearing UNIVERSAL JOINT and PROPELLER SHAFT is carefully B-A-L-A-N-C-E-D to reduce runout, whip and vibration to a minimum. Brake flanges are statically balanced or accurately machined all over. Complete shafts are dynamically balanced, *at high speed,* and factory tested to insure smooth operation. The scientific design of MECHANICS Roller Bearing UNIVERSAL JOINTS eliminates all useless, unbalanced weight. The original alignment and balance are not disturbed when replacing MECHANICS cross-and-bearing assemblies, because the bearings and pilots are accurately ground to insure absolute centering and perfect fit.



MECHANICS
Roller Bearing
UNIVERSAL JOINTS BW
For Cars, Trucks, Tractors, Farm Implements, Road Machinery, Industrial Equipment, Aircraft

Let our engineers show you how this exclusive MECHANICS Roller Bearing UNIVERSAL JOINTS advantages will help improve the operation of your product.

MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner
2022 Harrison Ave., Rockford, Ill.



ENGINEERS

Special opportunities for YOU in

SAN DIEGO

that sunshiny, smog-free city on the coast of

CALIFORNIA

Convair (Consolidated Vultee Aircraft Corporation) is now accepting applications for these following positions in its modern, progressive Engineering Department.

- Design Engineers
- Design Draftsmen
- Electrical Draftsmen
- Electronics Engineers
- Microwave Engineers
- Servo Engineers
- Aircraft Loftsmen
- Weight Engineers
- Aerodynamics Engineers
- Test Engineers
- Thermodynamics Engineers
- Aircraft Linesmen

WORKING FACTS: You get two holidays a week at Convair — overtime accomplished in 5-day week. Attractive salary ranges. An "engineers" engineering department . . . with stimulating, competent associates . . . and interesting, challenging, essential, long-range projects of a wide variety including — commercial aircraft, military aircraft, missiles, engineering research and electronic development. Excellent patent royalty arrangements. Top-notch retirement plan — better than-average life and health insurance. Complete progress-salary review for each person twice yearly. Opportunity for continuing engineering education.

LIVING FACTS: San Diego, with its wonderful residential areas, offers you and your family incomparable living. Ideal climate — cool, clean, dry. Mountains, desert, Mexico, Hollywood, Los Angeles, Pacific Ocean, beaches and bay — only hours or minutes away. It offers you a new way of Life.. pleasant, refreshing, happy.

If you qualify, you will receive generous travel allowances. *SEND COUPON* for free booklets and complete information.

THANK YOU

Mr. H. T. Brooks, *Engineering Department* 400
Convair, 3302 Pacific Hiway, San Diego, California

Please send me ***FREE*** booklets describing the Convair Opportunity for me and my Convair Application Form.

My name _____

Occupation _____

Address _____

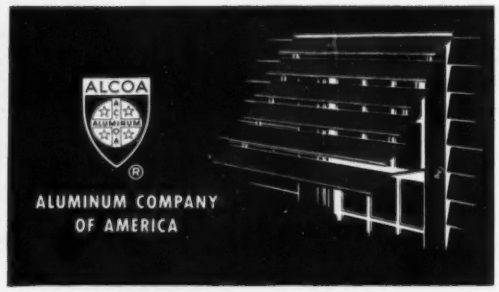
City _____ State _____

Q Can ALUMINUM be PAINTED?

A Yes, see ALCOA

Alcoa's finishing laboratories are continually improving and developing finishes for aluminum — painted, electroplated, anodized, plus chemical and mechanical treatments. For the latest information, simply write on your company letterhead to:

ALUMINUM COMPANY OF AMERICA
1950D Gulf Building • Pittsburgh 19, Penna.



Imperial

TRACING CLOTH FOR HARD PENCILS

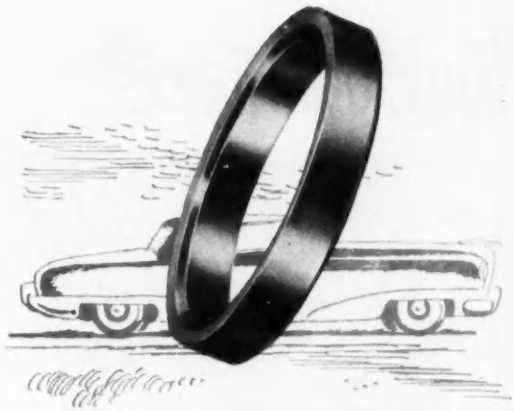
• Imperial Pencil Tracing Cloth has the same superbly uniform cloth foundation and transparency as the world famous Imperial Tracing Cloth. But it is distinguished by its special dull drawing surface, on which hard pencils can be used, giving clean, sharp, opaque, non-smudging lines.

Erasures are made easily, without damage. It gives sharp, contrasting prints of the finest lines. It resists the effects of time and wear, and does not become brittle or opaque.

Imperial Pencil Tracing Cloth is right for ink drawings as well.

Imperial
PENCIL TRACING CLOTH

SOLD BY LEADING STATIONERY AND DRAWING MATERIAL DEALERS EVERYWHERE



THE MASS PRODUCED motor vehicles of today require engine parts that assure maximum performance and dependability.

For fifty years Thompson Products has been making precision parts for cars, buses, trucks, tractors and industrial engines, both gasoline and diesel.

From cap screws in 1901, Thompson engineers have perfected such vital engine parts as valve seat inserts, whether for a Walker Bulldog Tank that is a vital link in our national defense, or one for the mass produced automobiles that are so essential to our way of living.

For engine performance you can take for granted: *count on* Thompson

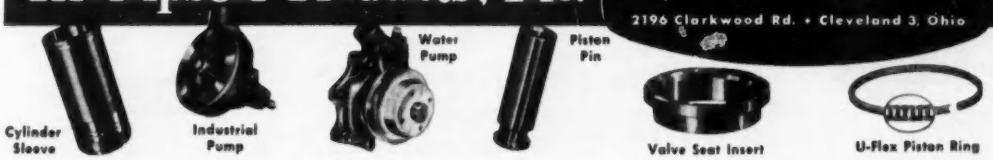
Along with valve seat inserts, Thompson's Special Products Division manufactures piston pins and cylinder sleeves—for the finest aircraft engines, heavy duty trucks and tractors, industrial engines as well as for passenger cars.

If you are having trouble with engine parts—if you need a better, more dependable supplier, just write or call Special Products Division, Thompson Products, Inc., 2196 Clarkwood, Cleveland 3, Ohio. You'll soon learn what car and plane makers have known for 50 years—*you can count on Thompson.*

Thompson Products, Inc.

SPECIAL PRODUCTS DIVISION

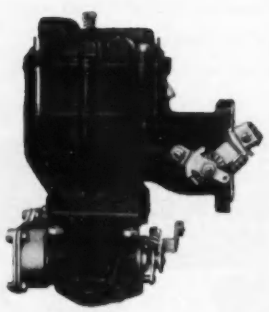
2196 Clarkwood Rd. • Cleveland 3, Ohio



Will he Buy Your Truck Next Time?

IT ALL DEPENDS ON PERFORMANCE and PERFORMANCE DEPENDS ON

Zenith CARBURETORS



No manufacturer could long exist in the competitive commercial vehicle field without drawing heavily on previous owners for new vehicle sales. It is perfectly obvious, no owner would buy the same make vehicle again and again unless it has delivered satisfactory performance. Therefore, it is just good business to see that every component contributes its share toward building owner loyalty. That's why manufacturers whose vehicles are Zenith* equipped measure carburetion costs in lasting terms rather than initial expense. In the field of heavy-duty carburetion, one name, Zenith, has stood for lasting satisfactory performance for over a quarter of a century. Zenith's rugged construction, strong idling, freedom from stalling and response to every demand make it the engineers' choice. For good will, it's good business to specify the best—Zenith for lasting performance.

*REG. U.S. PAT. OFF.

ZENITH CARBURETOR DIVISION OF
696 Hart Avenue • Detroit 14, Michigan

Bendix
AVIATION CORPORATION

Export Sales: Bendix International Division, 72 Fifth Avenue, New York 11, N. Y.

All America rushes to try . . .

SAGINAW HYDRAULIC POWER STEERING

*Now on 1952 model Cadillacs, Buicks and Oldsmobiles

A wave of enthusiasm is sweeping the nation. Saginaw hydraulic power steering is now available on passenger cars. It has been tried by America's motoring public and their praise knows no bounds. For "there is no steering like hydraulic power steering . . . and no power steering like Saginaw."

Saginaw power steering is new to the general public, but truck and bus operators have been familiar with its advantages since it was introduced in 1939 to make the steering of heavy-duty trucks and buses easier and safer. During World War II many of America's giant wheeled tanks were equipped by Saginaw—world's largest manufacturer of steering gears.

Saginaw power steering is remarkably simple in design—has fewer moving parts, fewer parts in all. "Wheel pull" is easily adjusted to the individual requirements of any car. Power helps only when help is needed. The driver has nothing to learn. Normal manual steering is automatically available in the event of hydraulic failure.

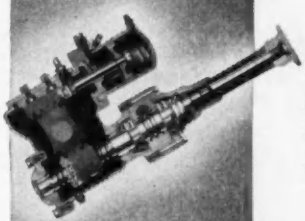
Saginaw power steering can be easily adapted to any automobile, and Saginaw engineers are available to work with car manufacturers at any time on new applications.

Write Saginaw Steering Gear Division of General Motors for full details.

IF IT'S EASY TO STEER . . . IT'S A SAGINAW GEAR

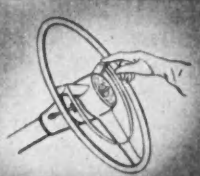
THIS . . .

Saginaw's recirculating ball steering gear provides almost frictionless operation that no other type of gear can equal. This principle has been proved on over a million automotive steering gears.



PLUS THIS . . .

Saginaw's hydraulic power steering gear gives a tremendous lift to driving ease. A hydraulic boost does the work . . . replaces driver effort with power steering.



EQUALS THIS . . .

Parking is a simple matter in a car equipped with Saginaw power steering. The smallest woman can spin the wheel of the biggest car with finger-tip ease.

*Optional equipment at extra cost

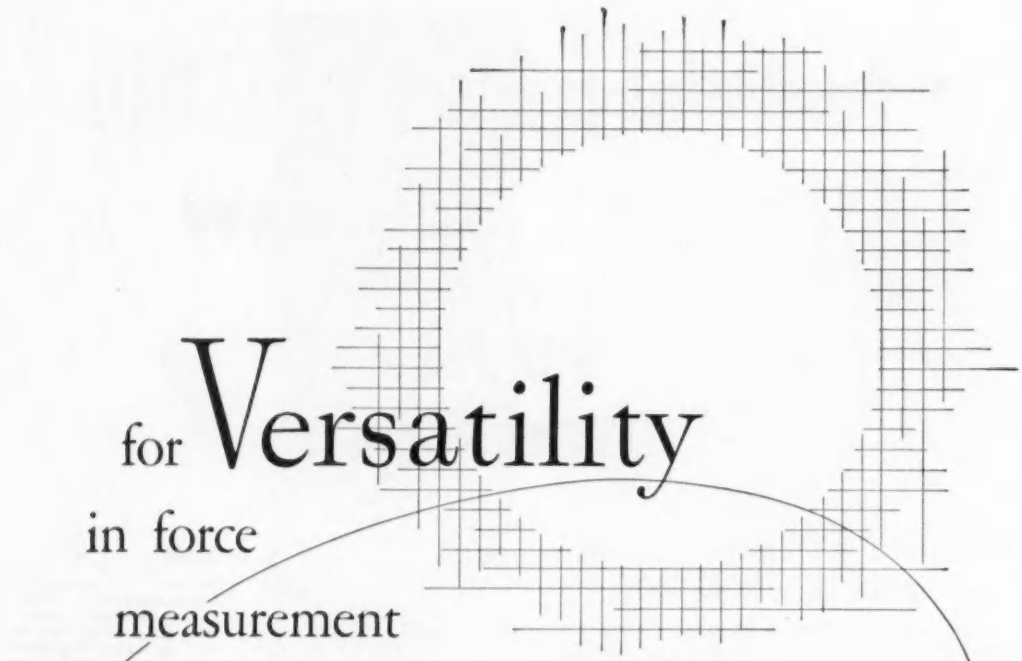
Saginaw

STEERING GEAR DIVISION

General Motors Corporation, Saginaw, Michigan

SSG PRODUCTS

STEERING GEAR ASSEMBLIES • STEERING LINKAGE ASSEMBLIES • PROPELLER SHAFTS • DIESEL ENGINE AND AIRCRAFT PARTS



for Versatility in force measurement

HAGAN THRUSTORQ

Whenever you have a force measuring problem—consider Hagan THRUSTORQ. This partial list of applications now being handled successfully by this simple and accurate device will give you some idea of its possibilities.

- cradle dynamometer measurement of airplane and automobile engines
- single cylinder engine test stands
- evaluating turbine blade shapes
- measuring torque of helicopter engines
- automatic batch weighing
- measuring thrust of jet engines and rockets
- testing piston rings
- chassis dynamometers
- axle testing machines

If you think Hagan THRUSTORQ may be the answer to some of your problems, write us about it. Our engineers are at your service.

HAGAN CORPORATION, HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA

HAGAN HALL BUROMIN CALGON

HAGAN THRUSTORQ
measuring thrust and torque *with air!*

the best-made

are made with **Turquoise** containing

100% *"Electronic" Graphite!

Unmatched smoothness! "Electronic" is Eagle's trade name for a blend of purest crystalline graphites reduced to micronic fineness in our patented Attrition Mill. Leads made with it 100% have a frictionless, smooth-gliding quality never approached before.

Non-crumbling points! The microscopic graphite particles of infinitely varied, close-interlocking shapes combine with the clay binder to form the strongest, longest-wearing lead structure ever made.

Perfect reproduction! Because millions more of these finer graphite particles are compacted in every inch of its lead, Turquoise deposits denser, blacker, even lines that reproduce to perfection.

Precision grading! 17 individual, exactly controlled formulas of Electronic graphite and clay keep the 17 degrees of Turquoise evenly spaced and as true as a plumb line.

EAGLE
TURQUOISE

Free Sample: Write for a free sample, naming this magazine, your dealer, and the grade you desire.

*®

EAGLE PENCIL COMPANY • NEW YORK • LONDON • TORONTO

Great names in the Automotive Industry

HENRY B. JOY

Henry B. Joy was one of the early backers of Packard and instrumental in getting that firm to locate in Detroit. Although he originally did not intend to take an active part in Packard's operation, a combination of circumstances forced Joy to take over the management of that company in order to prevent further financial loss to friends who had joined him in backing the enterprise.

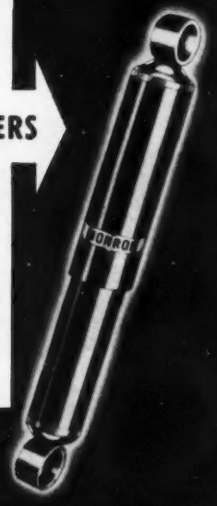
Among the first Packards produced under Joy's management was the "Grey Wolf", the first car to travel a mile in less than a minute. Another was the "Old Pacific" which made a record run from San Francisco to New York in 53 days.

In addition to his association with Packard, Henry B. Joy served a dozen other nationally-known firms in various executive capacities. During the Spanish-American War he was Chief Boatswain Mate on the U. S. S. Yosemite and during World War I he was a Lieutenant Colonel in the United States Air Force.

(One in a series of sketches about great automotive industry pioneers.)

MONROE—THE GREAT NAME IN SHOCK ABSORBERS

Together with better highways, improved ride control devices have greatly smoothed travel for America's autos, trucks and buses during the last half century. Monroe has pioneered in developing the best ride control products —shock absorbers, sway bars, struts and molded rubber parts. Today, Monroe ride control products are top choice among America's automotive engineers.



MONROE®

Monroe Shock Absorbers are standard equipment on more makes of new cars than any other brand of shock absorber.

MONROE AUTO EQUIPMENT CO.

Monroe, Mich.— World's Largest Maker of Ride Control Products

IT LOOKED SAFE

but it was
deadly poison.

A dose of Socialism
can be just as deadly.
It kills freedom . . .
leads to Communism.

Would you risk
a little POISON?

BOHN

BOHN ALUMINUM & BRASS CORPORATION
GENERAL OFFICES: LAFAYETTE BLDG. • DETROIT 26, MICHIGAN

FORGINGS • PISTONS • BEARINGS • EXTRUSIONS • CASTINGS
INGOTS • REFRIGERATION PRODUCTS • AIRCRAFT PARTS
AUTOMOTIVE REPLACEMENT PARTS

TELEVISION!

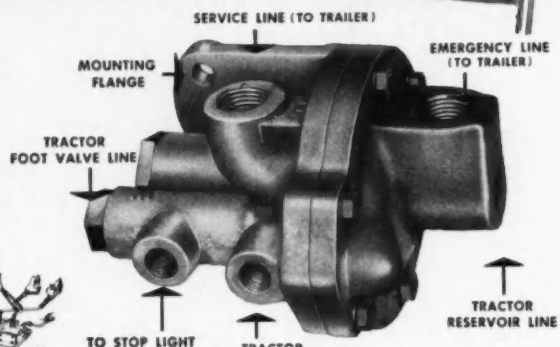
"American Forum of the Air"... Every Sunday Afternoon on NBC Television
Consult Your Newspaper for Time and Station

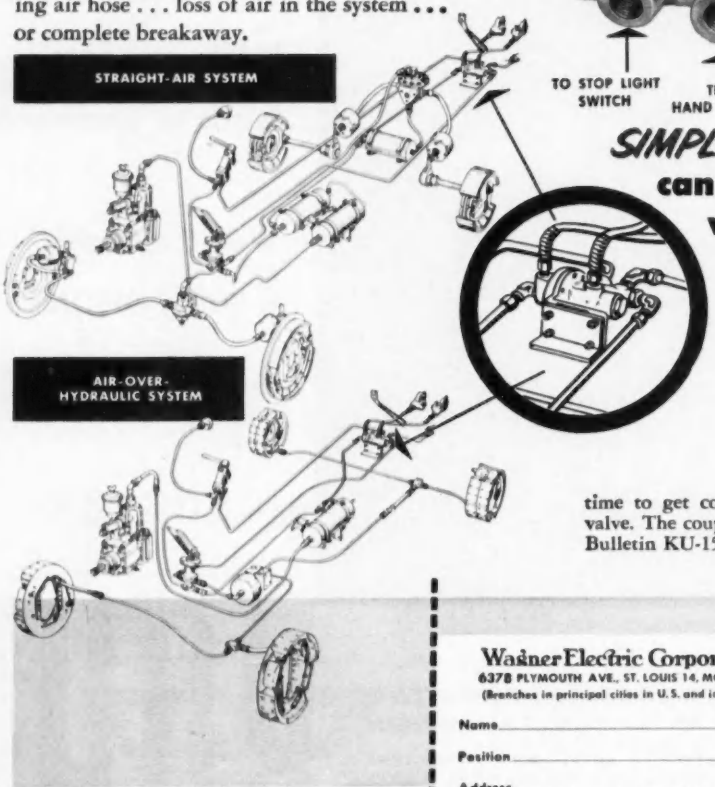
New Wagner Air Brake Safety Valve

gives tractor BREAKAWAY protection...

Here is the newest addition to the Wagner line of safe braking equipment for the trucking industry—a safety valve that automatically seals the tractor air system when the trailer is uncoupled.

This valve provides protection to costly rolling stock by preventing damages caused by—improper glad-hand connection . . . leaking air hose . . . loss of air in the system . . . or complete breakaway.





SIMPLE TO MOUNT—

can be applied to *all* vehicles equipped with air brakes

A few easy-to-make connections, and the Wagner Tractor Breakaway Valve becomes part of the air brake system. It provides service and emergency air line outlets, and replaces the two shut-off cocks formerly mounted on the truck chassis behind the cab. Now is the time to get complete information on this new valve. The coupon below will bring you copy of Bulletin KU-153. Mail it today.

Wagner Products Serve the Automotive and Electrical Industries

LOCKHEED HYDRAULIC BRAKE PARTS and FLUID
NoRoL . . CoMaX BRAKE LINING . . AIR BRAKES . . TACHOGRAPHS
ELECTRIC MOTORS . . TRANSFORMERS . . INDUSTRIAL BRAKES

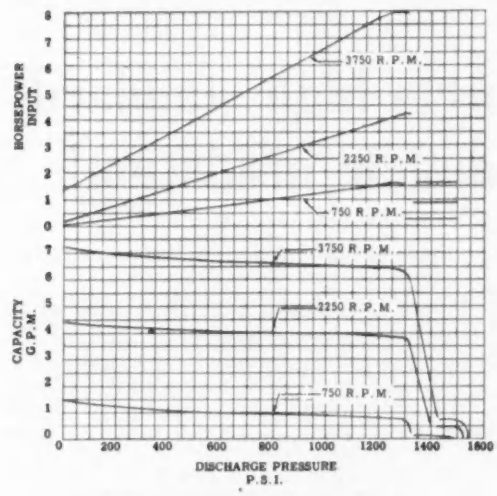
Wagner Electric Corporation
6378 PLYMOUTH AVE., ST. LOUIS 14, MO., U. S. A.
(Branches in principal cities in U. S. and in Canada)

Name_____
Position_____
Address_____
City_____ State_____
We operate_____ Vehicles
(NUMBER)

K52-13

SIX BIG REASONS for using Pesco unloading hydraulic gear pumps:

Capacity: 2 g. p. m. @ 1500 r. p. m. @ 1250 p. s. i. Maximum operating pressure 1500 p. s. i. Weight: 8.9 lbs. approx.



This chart shows performance characteristics of Pesco Unloading Pump. Write for detailed engineering drawings and performance data.

1. Fewer parts

2. Easier to recondition

3. Longer service between overhaul periods

4. Lighter weight

5. Lower initial cost

6. Lower maintenance costs

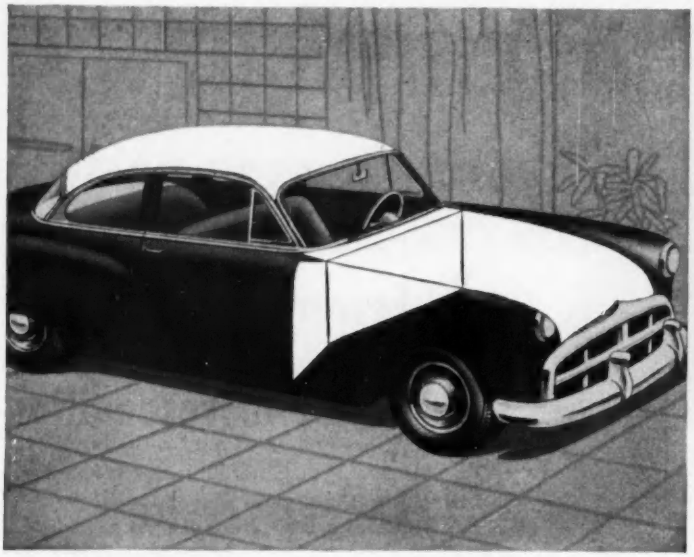
The Pesco *Unloading* Hydraulic Gear Pump is the most economical and dependable pump built for applications where a variable volume of hydraulic fluid is required. This Pesco pump automatically adjusts flow of fluid to increasing and decreasing demands of the hydraulic system. It incorporates a main and a pilot pump as well as unloading and relief valves in one unit. And it's "pressure loaded"—Pesco's exclusive, patented design principle that assures extremely high operating efficiencies over a long, trouble-free pump life because it *automatically* compensates for wear. For the complete story write today.

engineering Pesco production

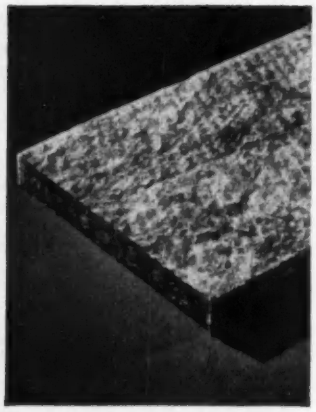
PRODUCTS DIVISION

BORG-WARNER CORPORATION

24700 NORTH MILES ROAD BEDFORD, OHIO



Passenger comfort is greatly increased in automobiles insulated with L·O·F Fiber·Glass. Easily installed, lightweight, low moisture content. For tops, under dash, on fire wall under hood, below package tray. High sound-insulating efficiency.



Super·Fine "B" Fiber offers excellent insulating properties against heat, cold, noise. Standard widths: 18", 24", 36" and 72". Temperature range: subzero F. to plus 450° F.

L·O·F Fiber·Glass meets high standards demanded for automobile insulation!

Proven glass technology and experience of Libbey·Owens·Ford provide industry with new quality source of supply

YEARS of experience in supplying fine glass products to the industry gained L·O·F a reputation for meeting the rigid automotive schedules and production requirements. Now, Libbey·Owens·Ford applies this long-time experience to supplying quality insulation for automobiles . . . L·O·F Fiber·Glass.

The proven glass technology and new plant facilities of Libbey·Owens·Ford are turning out top-grade insulation that meets the highest standards for sound, heat and cold insulation.

Look into the outstanding advantages of Fiber·Glass as insulation for tops, in the dash, on fire walls, under the hood and beneath package trays. If you are currently using fibrous glass, count on L·O·F as a new source ready to give you a quality product and delivery on schedule.

For technical data, or consultation on uses of Fiber·Glass in the automotive field, call the L·O·F Detroit office, 610 Fisher Building, Trinity 5-0080. Or write, wire or phone Libbey·Owens·Ford, Dept. F·G 642, Nicholas Building, Toledo 3, Ohio.

LOF FIBER·GLASS

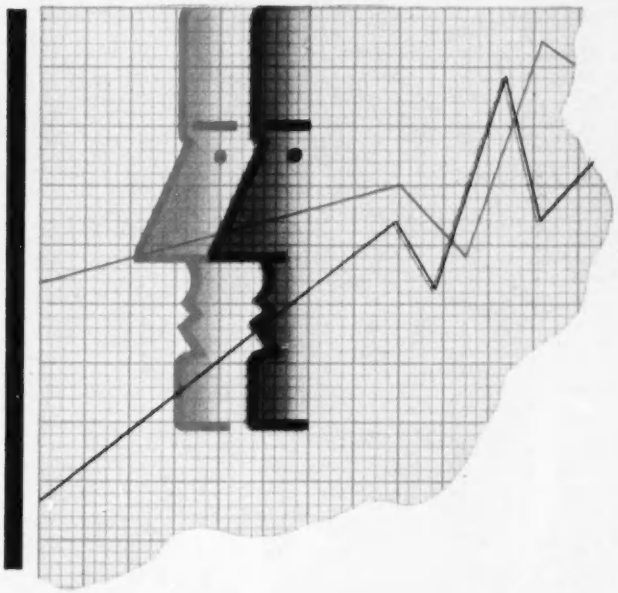
LIBBEY·OWENS·FORD GLASS COMPANY

FIBER·GLASS DIVISION

FIBER·GLASS

EQUIPMENT UNITS THAT BESPEAK QUALITY

TWO SPECIALISTS ARE BETTER THAN ONE



Working hand in hand with more than 300 automotive manufacturers, AC has developed 23 kinds of quality equipment units for their use.

This great body of experience and know-how is at your service, too. Just write to or 'phone the nearest AC office, listed below for your convenience.

• ADAPTERS (Drive) • AIR CLEANERS • AIR CLEANERS AND SILENCERS (Combination) • AMMETERS • BREATHERS (Crankcase) • CAPS (Radiator Pressure) • FLEXIBLE SHAFT ASSEMBLIES • FUEL PUMPS • FUEL AND VACUUM PUMPS (Combination) • FUEL FILTERS & STRAINERS • GASOLINE STRAINERS • GAUGES—AIR (Pressure) • GAUGES—GASOLINE • GAUGES—OIL (Pressure) • GAUGES—TEMPERATURE (Water, Oil) • OIL FILTERS (Lube) • PANELS (Instrument) • SPARK PLUGS • SPEEDOMETERS • TACHOMETERS • TERMINALS (Ignition Wire) • VALVES (Crankcase Ventilation)

AC

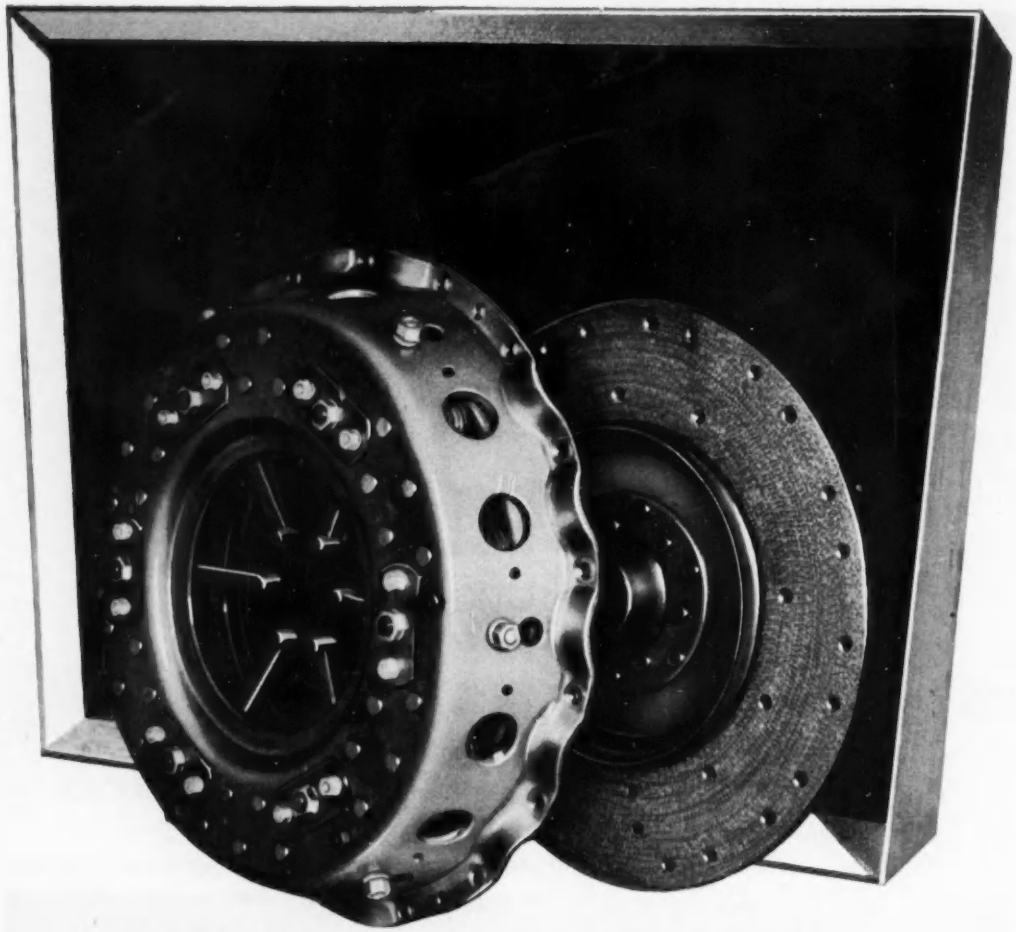
QUALITY PRODUCTS

1300 North Dort Hy. Flint 2, Michigan

General Motors Bldg. Detroit 2, Michigan

Lincoln Tower Bldg. Chicago 1, Illinois

AC SPARK PLUG DIVISION GENERAL MOTORS CORPORATION



a GIANT in Dependability

Long clutches provide smooth, positive power transmission for automotive vehicles. In every type of "proving ground"—city streets, byroads and highways, farm lands and military terrain, vehicle operators truly have found the Long clutch a giant in dependability.

Since 1922, Long clutches have equipped millions of passenger cars, trucks, buses, tractors and military vehicles.

LONG MANUFACTURING DIVISION BORG-WARNER CORPORATION
DETROIT 12, MICHIGAN and WINDSOR, ONTARIO

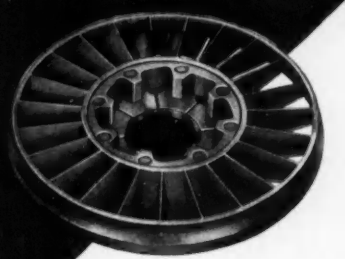
ENGINEERING BW PRODUCTION

LONG

CLUTCHES • RADIATORS • TORQUE CONVERTERS
OIL COOLERS

COSTS CUT VED

Thompson
Steel-Belted Piston

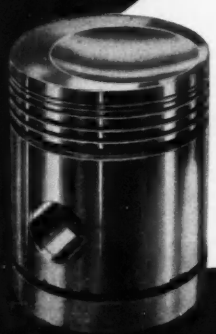


THOMPSON IS CASTING light metals
in forms and for uses that
were unthought of a short time ago.

Over 50 years of making precision parts
for the automotive and aircraft industries
has given Thompson engineers opportunities to
improve on many methods and materials.

Metals that must withstand high temperature—
metals that are strong—metals that are lightweight—
are cast by Thompson's Light Metals Division to very close tolerances.
They require less machining and finishing,
yet have dependable uniformity that eliminates costly scrap loss.
If finishing is required, Thompson's shop does the job better.

Whether it's a piston or torque converter like these illustrated,
or a part you thought couldn't be cast from light metal,
Thompson's creative engineers will be glad to show you where and how
to simplify your operations with light metal castings.

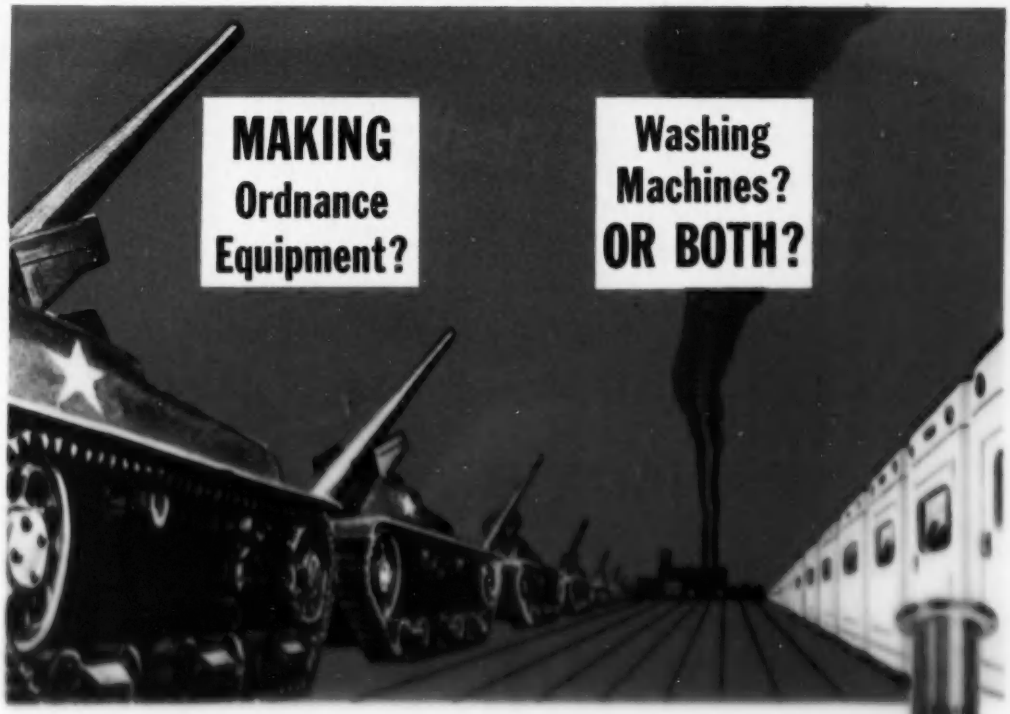


Diesel Permanent Mold Piston

2269 ASHLAND ROAD • • • CLEVELAND 3, OHIO

1898
MRC
MRC

1952
MARLIN-



On defense contracts or civilian products . . .

"COMPO"® and "POWDIRON"® bearings

bearings

ıg advantages

a simple press fit—a job

llurgy—need no costly, time-
machine tools and skilled manpower

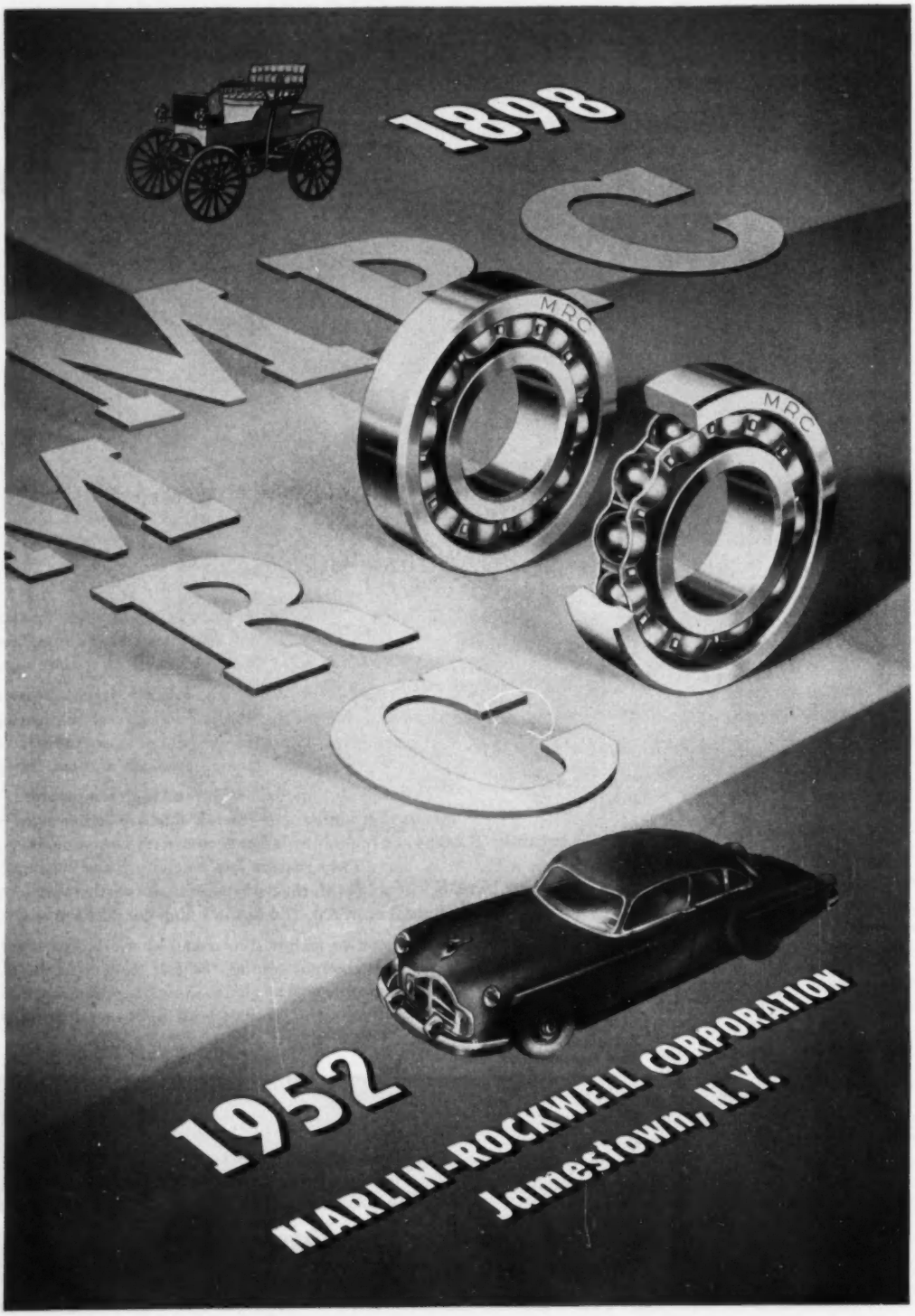
dvantages, too. Their
r thousands of operating hours,
ent in which they're installed!

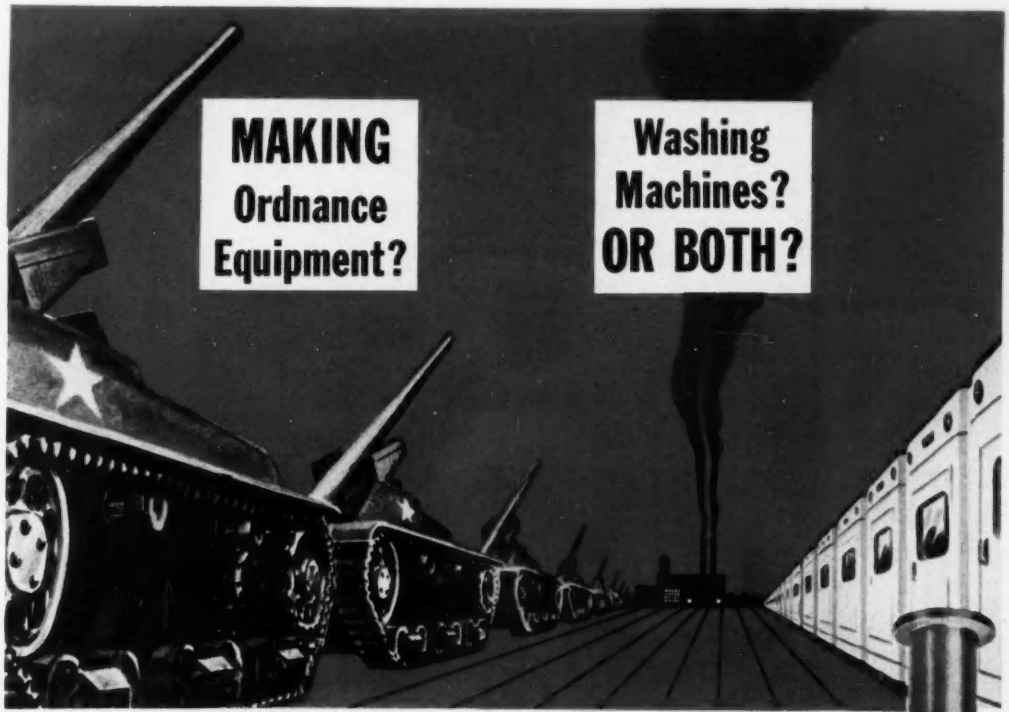
"POWDIRON" bearings—write for information on your company letterhead.

Better Buy Bound Brook

BOUND BROOK
OILLESS BEARING COMPANY

BOUND BROOK, N. J. • BOUND BROOK 9-0441
Manufacturers of bearings and parts — Established 1923


1898
MRC
MRC
MRC
1952
MARLIN-ROCKWELL CORPORATION
Jamestown, N.Y.



On defense contracts or civilian products . . .

"COMPO"® and "POWDIRON"® bearings

give you the same outstanding advantages

"COMPO" and "POWDIRON" bearings are installed by a simple press fit—a job that new personnel can learn in a jiffy.

They're *accurately* die-formed by *powder metallurgy*—need no costly, time-consuming machining to make them fit. They free your machine tools and skilled manpower for other, more important tasks.

"COMPO" and "POWDIRON" have exceptional *service* advantages, too. Their porous structure holds an ample lubricant supply for thousands of operating hours, without renewal. They often outlast the equipment in which they're installed!

Get the full facts on "COMPO" and "POWDIRON" bearings—write for information on your company letterhead.

Better Buy Bound Brook

"COMPO" • "POWDIRON" • "BOUND BROOK"

BOUND BROOK
OIL-LESS BEARING COMPANY

BOUND BROOK, N. J. • BOUND BROOK 9-0441
Manufacturers of bearings and parts — Established 1883

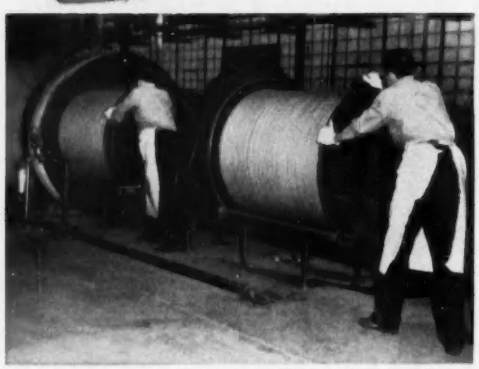


PHOTO COURTESY ELECTRIC AUTO-LITE

Hundreds of thousands of feet of Silastic insulated cable are now produced every week by various wire and cable companies. Sizes range from No. 22 to 500,000 circular mils. Applications range from wiring for the new House of Commons to ignition cable for Army ordnance vehicles and Navy control cable.

For complete information, call our nearest branch office, or

mail this coupon *Today!*

DOW CORNING CORPORATION
Dept. No. V-16 , Midland, Michigan

Please send me
- ☐ Silastic Facts No. 10 on properties and performance
- ☐ List of Silastic Fabricators

Name_____ Title_____

Company_____

Address_____

City_____ Zone_____ State_____

Silastic insulated wire and cable is in full scale commercial production now because Silastic retains both its physical and its dielectric properties at temperatures ranging from below —70° to over 500°F. Shock and vibration, hot oil, oxidation, corona, outdoor weathering and the mere passage of time have little if any effect on the properties of Silastic. With high thermal conductivity and good dielectric properties over a wide range of frequencies and at both high and low voltages, Silastic is unique among electrical insulating materials for traction motors and Banbury mixer motors as well as wire and cable. And no other resilient gasketing material is serviceable over so wide a temperature span or in contact with oil at such high temperatures.

*T. M. Reg. U. S. Pat. Office

ATLANTA
CHICAGO
CLEVELAND

DOW CORNING CORPORATION
MIDLAND, MICH.

DOW CORNING SILICONES

DALLAS
NEW YORK
LOS ANGELES
WASHINGTON, D. C.

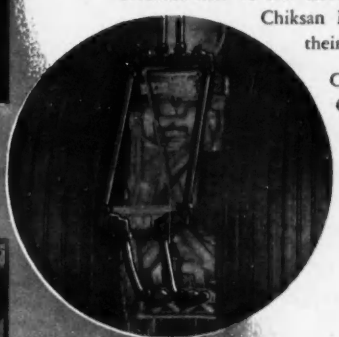
In Canada: Fiberglas Canada Ltd., Toronto
In England: Midland Silicones Ltd., London

WHEN A CONNIE FLEXES ITS LEG MUSCLES

...AND A NEPTUNE SPREADS ITS WINGS

Lockheed Engineering Turns to Chiksan to Turn the Trick

Tested according to military specification MIL-J-5513 (AN-J-10) Chiksan Aero-Hydraulic Swivel Joints were proved more than adequate for use in Aircraft Hydraulic Systems. Above, they are shown as installed in the landing gear of the U. S. Navy's newest Neptune anti-submarine patrol bomber.



Chiksan Ball Bearing Swivel Joints have a part in bringing planes to a stop. Here, too, the liquid of hydraulic systems must flow in uninterrupted stream. Chiksan surpasses all standards set down for both civilian and military requirements—serves in braking mechanisms of Super Constellations, Neptunes and many other planes.

These safe feather-touch landings of Lockheed's new Super Constellation can be partly accounted for by the smooth, sure operation of the well-engineered hydraulic system using Chiksan Ball Bearing Swivel Joints.

THE SUPER CONSTELLATION, newest in Lockheed's fleet of transports, and the Navy's newest Neptune, tough-taloned bird of prey, are both evidence that we can "Look to Lockheed for Leadership". Both rely upon Chiksan Ball Bearing Swivel Joints to turn corners in their hydraulic systems—to flex their metal joints.

Chiksan takes such tough assignments in its stride. For Chiksan Hydraulic Joints are made for jobs where precision is the rule. Although used in 1, 2, and 3,000 psi systems these joints are tested by Chiksan's Research and Development Department in the presence of bitter cold and searing heat—under pressures as high as 10,000 psi and under the relentless driving force of continual use.

Whether the job is to keep planes flying or industry's life-blood flowing—to hasten manufacturing process and expedite transportation—to feed the veins of industry and speed the course of science and invention, there you will find Chiksan applications—Ball Bearing Swivel Joints tooled to exacting tolerances, flexing the muscles of Progress—adding sinew and flexibility to the flow of gas, liquid and modern living.

The Flow of Enterprise Relies on

CHIKSAN

Ball-Bearing Swivel Joints

CHIKSAN TRADE MARK REG.

If plant, process or product needs speeding or improving—if flow of liquid or gas or flexibility of metal is a factor, call upon the Research and Development Division of Chiksan. There's probably a better method awaiting your service that Chiksan has proved in performance or can devise for your special need.

Representatives in principal cities
Write today for Catalog 2A "Aircraft Swivel Joints" — Dept. 4-SJ

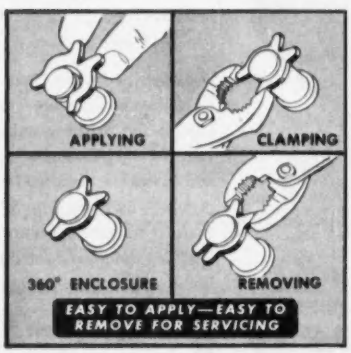
CHIKSAN COMPANY • BREA, CALIFORNIA • Chicago 28, Illinois • Newark 2, New Jersey

Well Equipment Mfg. Corp., Houston 1, Texas, A Division of Chiksan Company • Chiksan Export Company, Brea, California • Newark 2, N. J.

WHY SOME DESIGN ENGINEERS DESERVE MORE MONEY THAN OTHERS

● The highest paid design engineer you know has a simple formula. He not only continually strives to "design out the labor," but—like a competent diagnostician—he makes a thorough check before prescribing the "medicine" for even the smallest parts, like fasteners. He knows from experience that their selection is well worth his careful consideration, because the *right* choice brings appreciable savings in production time and costs.

Standard X Washers *do* save time and money. That's why the nation's most successful design engineers are specifying them more and more frequently. Judge how they fit into your designs. They provide a profitable solution to many a problem!

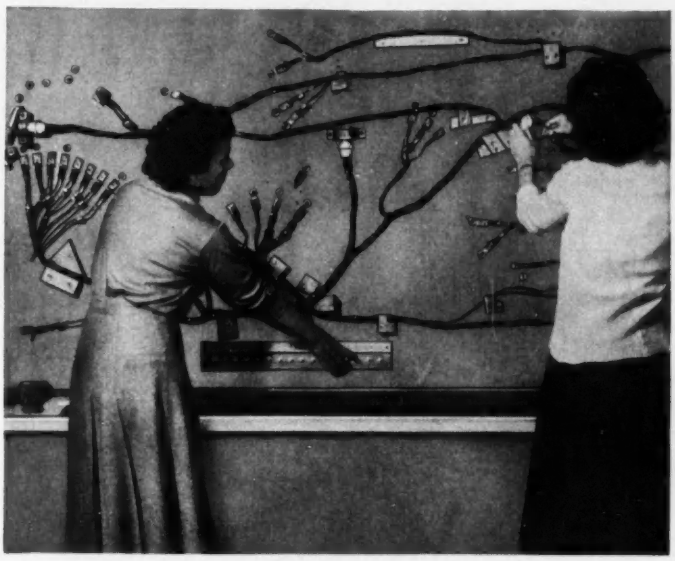


A pair of ordinary pliers quickly and easily presses Standard X Washers to a positive 360° closure—and removes them just as quickly for servicing. Standard X Washers strengthen your product—eliminate consumer kickbacks. Grooved pins are made available for all sizes of Standard X Washers . . . parallel or headed type pins made to your specifications. Send your print for a prompt quotation.

Write for STANDARD'S Detailed Bulletin Today

STANDARD **Locknut and Lockwasher, Inc.**
510 NORTH CAPITOL AVE • INDIANAPOLIS 4, INDIANA

Let MONOWATT help you with your HARNESS ASSEMBLY PROBLEMS



Visual inspection and continuity checking are important steps in the testing of Monowatt pre-cabled harness assemblies for aircraft, ordnance vehicles, or electrically operated instruments and weapons.

The Facilities and Capacity

Monowatt has both the physical facilities and reserve capacity for mass-production of even the most complex harness assemblies. Included are rubber and plastics molding equipment; a metal fabricating plant; a complete and modern plating department; AN and Ordnance connector assembly departments; wire and cable forming facilities; and a complete testing laboratory (see photo left).

The Production Follow-Through

Because of these facilities, controlled and operated by skilled craftsmen with years of experience in the production of harness assemblies, Monowatt can offer complete wiring assemblies for military use at competitive prices and on a fast-delivery basis.

Monowatt is now supplying harness assemblies to such companies as Studebaker, Reo Motors and Willys-Overland.

For Complete Information

mail the coupon. Let Monowatt bring its knowledge, experience and facilities to bear on your harness assembly problems.

And you can count on MONOWATT for all types of electrical components — made to your specifications

MONOWATT

AN and Ordnance Connectors
For aircraft, ordnance vehicles, instruments and electronic equipment

Wiring Devices
For large-scale production of electrical equipment and appliances

Wiring Components
Made to your specifications

Monowatt Department D-4, General Electric Company
95 Hathaway St., Providence 7, R. I.

☐ Please send Catalog D-1 — Electrical Connectors and Wiring Assemblies for Aircraft, Ordnance and Electronic Equipment.

☐ Please quote on attached specifications.

Name.....

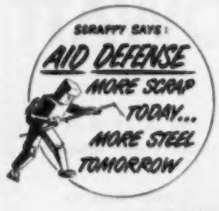
Title.....

Company.....

Address.....

MONOWATT
A DEPARTMENT OF GENERAL ELECTRIC COMPANY, PROVIDENCE 7, R. I.

Grandpa Never Threw a Thing Away



It's only human to want to hold on to things after they've outlived their usefulness. That's why today millions of tons of worn-out and obsolete equipment and machinery are lying forgotten in the country's plants and factories and on farms.

The steel industry needs these millions of tons of dormant scrap, needs it in the worst way. With this vital dormant scrap the entire steel supply picture would brighten up, with more steel for everybody. But without it, the steel industry cannot hope to keep up production at present levels.

Call in a scrap dealer now, today. He will buy your dormant scrap and start it moving toward the steel mills.

BETHLEHEM STEEL

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

More Scrap Today... More Steel Tomorrow

Bendix Products Division

FIRST IN FUEL METERING

Planning for the Future— Building for the Present

Bendix Products' position of leadership in fuel metering and landing gear has been attained through its unique ability to plan as well as to produce.

The specialized knowledge of trained engineers and the vast research facilities of Bendix are constantly employed in the development of new and better products.

Assembled here, also, is the most modern and comprehensive machinery in the industry to assure production in quantity and precision in quality to meet your most exacting demands.

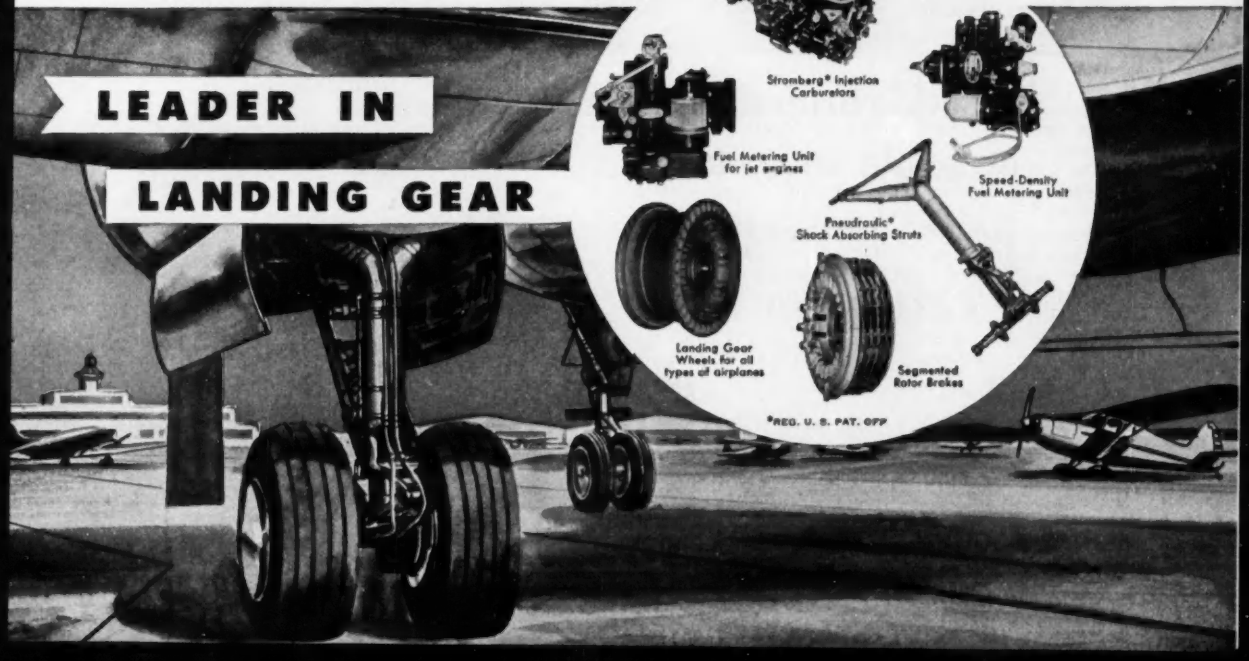
Whether your problem is planning or producing fuel metering, carburetion, struts, brakes or wheels, you will find Bendix Products is best qualified to do the job.

BENDIX · PRODUCTS DIVISION · SOUTH BEND

Bendix AVIATION CORPORATION

Export Sales: Bendix International Division, 72 Fifth Avenue, New York 11, N. Y.

LEADER IN LANDING GEAR


Stromberg® Injection Carburetors
Fuel Metering Unit for jet engines
Speed-Density Fuel Metering Unit
Pneudraulic® Shock Absorbing Struts
Landing Gear Wheels for all types of airplanes
Segmented Rotor Brakes

®REG. U. S. PAT. OFF

Pictured is the Chase XC-123
— prototype of the C-123

Chase C-123 Avitruc
power packages built by

ROHR

World's largest producer of ready-to-install power packages for airplanes

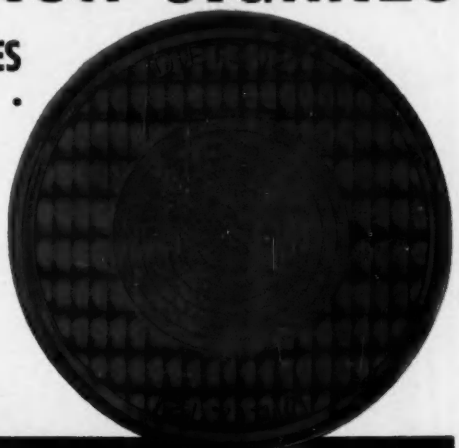
in Chula Vista, California ... 9 miles from San Diego

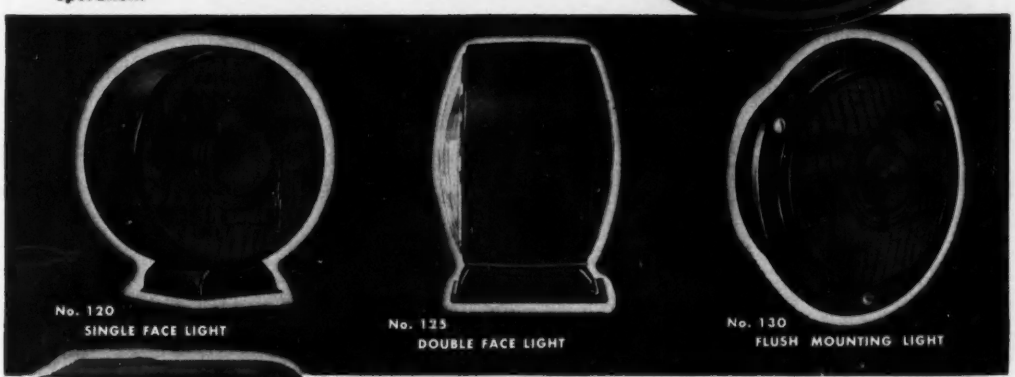
ROHR
AIRCRAFT CORPORATION

100% GREATER VISIBILITY IN NEW DIRECTION SIGNALS

EXCLUSIVE NEW DIETZ LUCITE LENSES PROVIDE EXTRA ADVANTAGES • • • •

- **Photometric tests prove DIETZ Lucite Lenses transmit twice as much light as glass. Far exceed I.C.C. and latest S.A.E. specifications.**
- **Exclusive design Lucite plastic Lenses give higher visibility, are practically unbreakable, last much longer.**
- **DIETZ Light Units are much sturdier. Heavy rubber pad protects Lights, waterproofs mounting.**
- **No disassembly needed when mounting. A single screw provides for changing bulb and lenses.**
- **Simplified, sturdy 2 bolt mounting of Single and Double Face Units—4 positions, vertically or horizontally. Can't jar loose.**
- **Self-cancelling or non-cancelling Switches with Flashers. E.T.L. tested for over 175,000 cycles of continuous operation.**





No. 120
SINGLE FACE LIGHT

No. 125
DOUBLE FACE LIGHT

No. 130
FLUSH MOUNTING LIGHT

DIETZ SELF-CANCELLING SWITCH No. 111-C
DIETZ NON-CANCELLING SWITCH No. 111-N

No. 120-A No. 125-A No. 130-A

CLASS "A"—TYPE 2 SIGNAL LIGHTS
WITH DIRECTION ARROWS

For unmistakable signalling—vivid Amber arrows on black backgrounds. Single Face, Double Face and Flush Mounting models available individually and in popular Sets. Typical fine DIETZ construction, fully tested and approved.

As original equipment DIETZ Class "A"—Type 1 Direction Signal Lights, with their brilliant Lucite plastic Lenses, are impressive accessories. But, of greater importance, they provide a definite added safety feature for your vehicles. Class "A"—Type 1 Direction Signal Lights are the ONLY Lights approved by many States, and other States have legislation pending confining approval to this Type. DIETZ Class "A"—Type 1 Lights far exceed all I.C.C. and latest S.A.E. specifications. Write for complete information on this and other DIETZ Safety Lighting original equipment today! R. E. Dietz Company, 225 Wilkinson St., Syracuse 1, N. Y.

OVER A CENTURY OF *Safety* LIGHTING **DIETZ**

Charles Edward Johnson

1875 • 1952

CHARLES E. JOHNSON was born on a farm near Newaygo, Michigan, in 1875. He became, in turn, a woodworker, a cabinet maker, a laborer in a bicycle factory. He designed camshafts for Muskegon Motor Specialties and became tool room foreman for Continental Motors.

In 1911, with Paul R. Beardsley, he founded the Piston Ring Company, which later became the Sealed Power Corporation. They produced their first piston rings at night and during weekends, while holding other jobs. The quality of the rings soon brought orders that required full-time operation. The two partners then went on the payroll at 30 cents an hour each.

Mr. Johnson's inventive genius resulted in better and better piston rings. Ultimately he held dozens of patents and his insatiable interest in things mechanical persisted to the instant of his death which took place as he was working on the engine of his automobile.

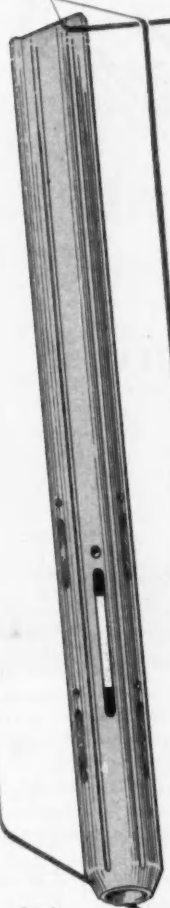
Today, Sealed Power Piston Rings, Pistons, Cylinder Sleeves, and Motor Parts are known and respected all over the world. Sealed Power Piston Rings are used as original equipment by manufacturers of more than 80% of all makes of passenger cars and commercial engines.

The story of Charles E. Johnson and Sealed Power is another splendid chapter in the American saga of free enterprise.

Sealed Power Corporation

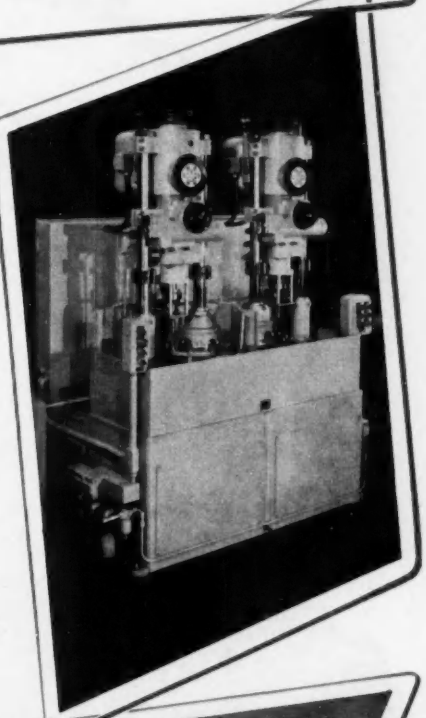
MUSKEGON, MICHIGAN

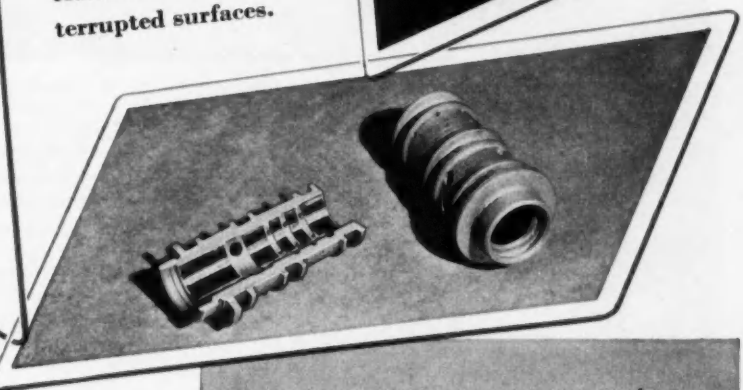
PRECISION
in Hydraguide steering control generated by Microhoning



Hardened steel valve sleeves held to .0002" tolerance for size, geometry and alignment. Edges of control surfaces made sharp and clean.

New guided type MICROMOLD tool and MICROHONER machine makes possible the productive generation of these precision tolerances in hard, interrupted surfaces.





For complete information on MICROHONING Interrupted Surfaces write for Cross Hatch Vol. 3. No. 3.

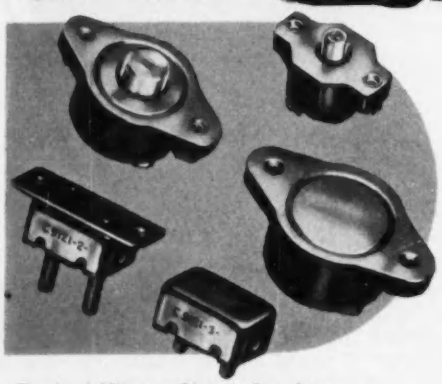
MICROMATIC HONE CORPORATION
8100 SCHOOLCRAFT AVENUE • DETROIT 4, MICHIGAN
District Field Offices: 1323 S. Santa Fe Avenue, Los Angeles 21, California • 206 S. Main Street, Rockford, Illinois • 231 S. Pendleton Avenue, Pendleton, Indiana • MICRO-MOLD Manufacturing Division, Boston Post Road, Guilford, Connecticut • 55 George Street, Brantford, Ontario, Canada

KLIXON

Circuit Breakers

Keep Equipment "On The Road"

with Positive Electrical Circuit Protection



Typical Klixon Circuit Breakers

Operating records of numerous fleets — trucks, busses, taxicabs and other mobile equipment — conclusively prove that Klixon Circuit Breakers permanently safeguard electrical circuits from possible shorts and harmful overloads.

You can benefit by their experiences by installing Klixon Circuit Breakers on your equipment. They'll keep your equipment rolling by preventing delays due to fuse burnouts and fuse replacements.

Rugged and dependable, their operation is unaffected by shock, motion, or vibration.

Klixon Circuit Breakers are available in a wide range of types and ratings. Write for information.

KLIXON

SPENCER THERMOSTAT

Division of Metals & Controls Corp.

1504 FOREST ST., ATTLEBORO, MASS.

Globe-Union feature-packed design makes

Battery-happy equipment

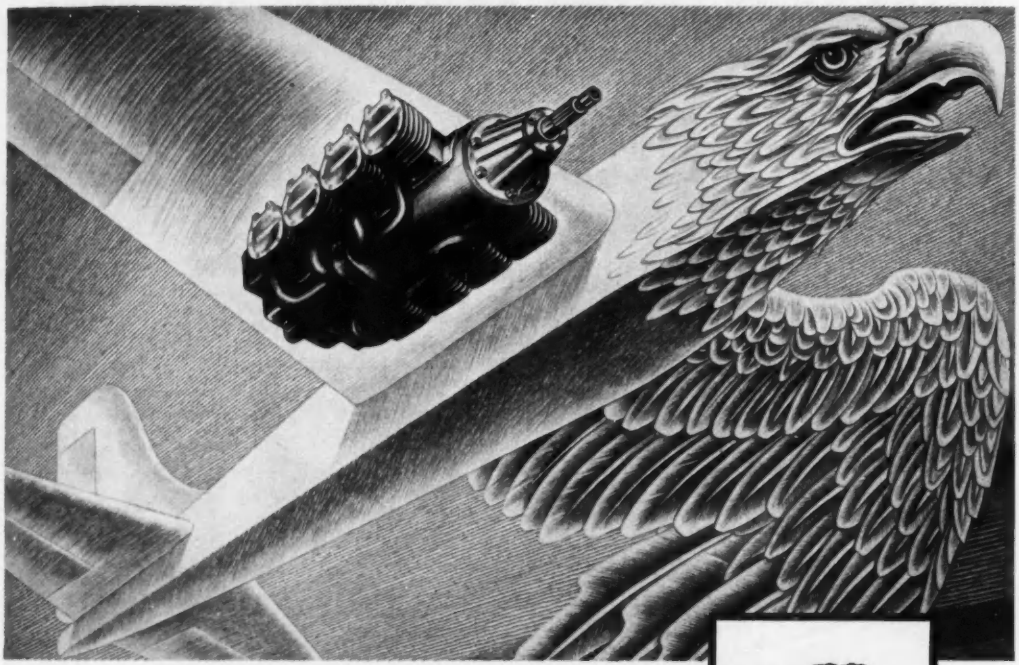
FLEXIBLE, rubber-mounted posts absorb shock, prevent battery leakage and snapping of terminals.
"NONSPILL" safety vents prevent acid spilling over—protect adjacent vehicle parts.
HIGH-POROSITY separators permit quick release of power.
PEBBLED SURFACE and staggered construction of interlocking V-shaped grid bars hold superactive oxides in place — assure longer life.
CHEMICALLY SET plates promote more power, prolong battery performance.
If it's engineered and made by Globe Union—it's RIGHT FROM THE START

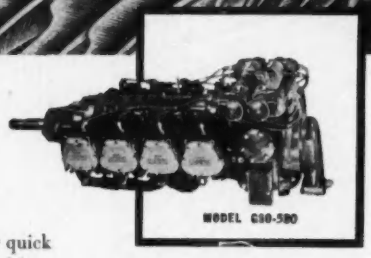
Builders of quality batteries for original equipment and for mass merchandising under the trade names of GLOBE-UNION and leading private brands.

GLOBE-UNION

GLOBE-UNION INC. MILWAUKEE 1, WISCONSIN

Battery Production Plants At: ATLANTA, GA. • BOSTON, MASS. • CINCINNATI, O. • DALLAS, TEXAS • EMPORIA, KANS. • HASTINGS-ON-HUDSON, N. Y. • LOS ANGELES, CALIF. • MEMPHIS, TENN. • MINERAL RIDGE, O. • OREGON CITY, ORE. • PHILADELPHIA, PA. • REIDSVILLE, N. C.





There's a new "beat" in this eagle's heart

A versatile aircraft engine with reserve power for quick take-offs, military hedge-hopping, more lift! *Geared* for smoother operation; "*opposed*" *design* for practical compactness; *supercharged* for greater power; the only 400-horsepower air-cooled engine being produced! That's the unique power plant now available through Lycoming research and precision production.

Whether you require air-cooled power for aircraft or ground applications—or whether your need is precision machining, product development, or high-volume production—Lycoming offers extensive facilities and well-rounded experience. Long famous for its aircraft engines, Lycoming also meets the most exacting and diverse requirements in many fields, both military and industrial.

Whatever your problem—look to Lycoming!

To put more "thrust" in aircraft calls for an engine with ready reserve power. Now, with a new "heart"—400-horse size—

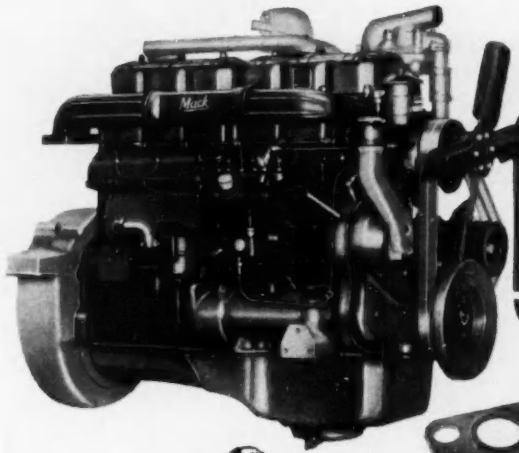
Lycoming precision production gives extra power for peak performance.

AIR-COOLED ENGINES FOR AIRCRAFT AND INDUSTRIAL USES • PRECISION-AND-VOLUME MACHINE PARTS • GRAY-IRON CASTINGS • STEEL-PLATE FABRICATION

LOOK TO **LYCOMING** FOR RESEARCH FOR PRECISION PRODUCTION

LYCOMING-SPENCER DIVISION, WILLIAMSPORT, PA.
BRIDGEPORT-LYCOMING DIVISION, STRATFORD, CONN.

AVCO MANUFACTURING CORPORATION



SEALED TO ORDER BY VICTOR

Mack TRUCKS

PATENTED HEAD GASKET PROTECTS MACK ENGINE PERFORMANCE

A feature of Mack diesel engine-head sealing is the use of highly compressible Victoprene grommets retained by bond to an inner steel member at water holes in the gasket. Combined with special heavy-duty metal-asbestos construction, this feature insures equally efficient and dependable sealing of coolant or lubricant openings and combustion chambers.

Victor Gives Sealing Satisfaction Since 1909

Mack's exacting requirements for this special gasket were ably filled by Victor. Leading in automotive sealing products development since 1909, Victor has the know-how to give effective help on special problems. Whether you write the specifications, or invite Victor's help, you get full benefit of unmatched facilities for developing, testing, and manufacturing gaskets and oil seals for all requirements.

LEAKPROOF COOLANT SEALING WITH VICTOPRENE

Designed especially for Mack diesel engines, this gasket combines heavy-duty sealing of combustion chambers with durable, leakproof sealing of water ways which are outside the line of studs. Grommets of Victoprene, a Victor-developed synthetic rubber, are molded-in and chemically bonded to a metal retaining member at water openings. Unaffected by engine temperatures, Victoprene is highly efficient in retaining hard-to-hold anti-freeze solutions.

For maximum resistance to blowout, breakdown, and corrosion, gasket construction utilizes Victor-milled long fiber asbestos filler, with copper case top and bottom, reinforced with steel at combustion chamber openings.

Where can we help you get better sealing?

Victor Manufacturing & Gasket Co., *and its affiliate,* Victor Sealing Products Co., Inc., P. O. Box 1333, Chicago 90, Ill.

VICTOR

"ORIGINAL EQUIPMENT"

Gaskets and Oil Seals

SEALING PRODUCTS EXCLUSIVELY

IMPROVED BEARING DESIGN

means longer tractor life!

Farmers today are quick to notice that tractors and implements equipped with Bower Spher-O-Honed bearings operate efficiently with little or no bearing maintenance! This, and other important end-product advantages, can be traced directly to specific Bower engineering advances such as spherical roll-heads and flange surface, generous oil groove and smooth, precisely finished races. Put this extra value to work for you; specify Bower Spher-O-Honed bearings for your product!

BOWER ROLLER BEARING COMPANY
Detroit 14, Michigan

BOWER

SPHER-O-HONED

ROLLER BEARINGS

You see more and more new designs for automotive equipment. Axles are a good example . . . if you want an axle to fit a new or special vehicle, come to Clark. You find the essential basis of broad automotive experience that teaches when to stick to the old ways and when to dare the new. You'll find it good business to work with Clark
CLARK

SEE NEXT PAGE FOR MORE ABOUT CLARK PRODUCTS

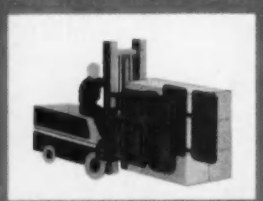
CLARK EQUIPMENT COMPANY, Buchanan, Michigan

Other Plants: BATTLE CREEK, JACKSON, MICHIGAN

MORE FOR YOUR MONEY IN CLARK Attachments

You *get more* out of your Clark fork-lift trucks when you use CLARK attachments. You get literally many machines in one — machines of vastly broadened usefulness that will do more things; and you get it at a cost that is quickly and painlessly absorbed.

As an easy move toward getting More for Your Money, ask the Clark dealer about "attachments"—he's listed in the Yellow Pages of your Phone Directory; and send the coupon for helpful literature.

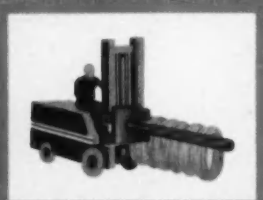


CARTON CLAMP

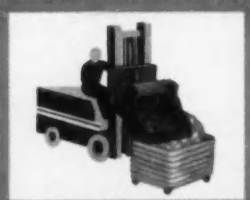
BRICK FORKS

CRANE

ROTATING DEVICE

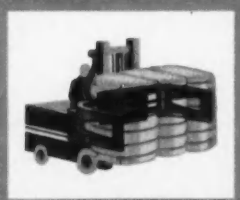


RAM



SHOVEL

BARTEL DEVICE



CLAMP

CLARK ELECTRIC AND GAS POWERED **FORK TRUCKS**

AND POWERED HAND TRUCKS · INDUSTRIAL TOWING TRACTORS

INDUSTRIAL TRUCK DIVISION · CLARK EQUIPMENT COMPANY · BATTLE CREEK 35, MICH.

Please send: ☐ Basic Facts ☐ Condensed Catalog

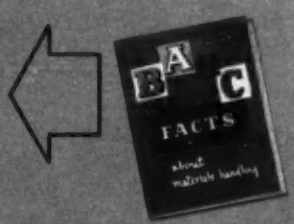
Name_____

Firm Name_____

Street_____

City_____ Zone____ State_____

AUTHORIZED CLARK INDUSTRIAL TRUCK PARTS AND SERVICE STATIONS IN STRATEGIC LOCATIONS



By all means send for and study CLARK's newest booklet, "Basic Facts About Materials Handling." It's too good to miss.

PRODUCTS OF CLARK—TRANSMISSIONS · FORK TRUCKS & TRACTORS
POWERED HAND TRUCKS · GEARS & FORGINGS · RAILWAY CAR TRUCKS
AXLE HOUSINGS · ELECTRIC STEEL CASTINGS · AXLES · TRACTOR UNITS

Always the same . . . product quality that never varies . . . that's the secret of Aeroquip's leadership. Nothing is spared in time, money and effort to obtain the newest, most accurate inspection equipment to assure the Aeroquip standard, highest in the industry. That is why Aeroquip Products are "Always First" in quality.

- Flexible Hose Lines
- Detachable, Reusable Fittings
- Self-Sealing Couplings
- Breakaway Couplings

Aeroquip

AEROQUIP CORPORATION, JACKSON, MICHIGAN

SALES OFFICES: BURBANK, CALIF. • DAYTON, OHIO • HAGERSTOWN, MD. • HIGH POINT, N. C. • MIAMI SPRINGS, FLA. MINNEAPOLIS, MINN. • PORTLAND, ORE. • WICHITA, KAN. • TORONTO, CANADA

AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

FOR EXTREME ACCURACY

in the measurement of average speed of rotation

STANDARD Chrono-Tachometer

UNIVERSALLY USED

Wherever precise measurement of speed of rotation is required.

Ruggedly built for continuous service, in portable cases or ready for panel mounting . . . We also design and build speed measuring instruments for many special purposes.

Your inquiry is invited

Write for Booklet 173-A

ESTABLISHED 1884

STANDARD

ELAPSED TIME — SIXTY-EIGHT YEARS

THE STANDARD ELECTRIC TIME COMPANY

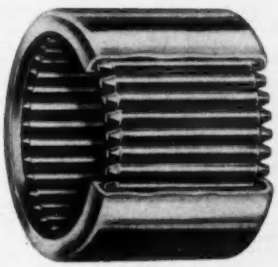
87 Logan Street, Springfield 2, Massachusetts

TIMERS AND CHRONO-TACHOMETERS
LABORATORY PANELS
PROGRAM CLOCK SYSTEMS PIPELINE ANALYZERS

when high capacity pays off...

Torrington Needle Bearings are designed to handle heavy loads. A full complement of small diameter rollers distributes the load evenly over a large area. Thus—for a given O.D.—a Needle Bearing has greater rated radial load capacity than any other type of anti-friction bearing.

Other Needle Bearing advantages—compact size, light weight, ease of installation and maintenance—pay off, too. So let our engineers help you—as they have many others—take full advantage of Torrington Needle Bearings in *your* product.



THE TORRINGTON COMPANY

Torrington, Conn. South Bend 21, Ind.

District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON *NEEDLE* **BEARINGS**

Needle • Spherical Roller • Tapered Roller • Straight Roller • Ball • Needle Rollers

NEW ARMY "OTTER" Newest, most versatile of Army amphibious vehicles. Scheduled for production by the Pontiac Division of General Motors, the "Otter," boasts the Army, can turn on a dime, swim, plow through mud and travel on dry land at speeds up to 36 miles an hour. Its efficient heating system relies on the South Wind "978"... for heating personnel and preheating the power plant.

NEW REO "EAGER BEAVER" Army's newest six-by-six . . . 2½ ton heavy duty utility vehicle and cargo carrier. Can travel up 60% grades or under water. A South Wind "978" defrosts windshield, keeps cab and personnel warm.

GENERAL PERSHING The Army's World War II medium tank — the M26. Personnel of this mighty, armored Goliath are kept comfortably warm, thanks to a South Wind "978" heater.

"MOBILITY RETAINED IN WINTER" WITH NEW MILITARY HEATER

South Wind "978" Preheats, Heats and Defrosts Army Vehicles Even at 70° Below

Keeping vital equipment functioning . . . skilled personnel warm under the severest weather conditions: It's one of many problems faced by the nation's new, more mobile, harder striking armed forces. A problem now successfully solved by an amazing new military heater—the South Wind "978."

Simplified in design. Compact. This rugged forced air heater preheats, heats, and defrosts in any type of military vehicle—in temperatures as low as 70° below zero. Dependably safe because the combustion air system is completely separated from the ventilating air stream. Always fast acting because warm air circulation doesn't depend on engine heat.

Built to Army Ordnance Specifications, the "978" has been standardized by the Army for its winterization program. And, because of its many exclusive advantages, promises to be influential in fashioning future designs for commercial car heating, too.

IMPORTANT: For complete details *plus* experienced engineering assistance, wire, write or phone Stewart-Warner Corporation, South Wind Division, Dept. N-42, 1514 Drover Street, Indianapolis 7, Indiana.

STEWART-WARNER

South Wind

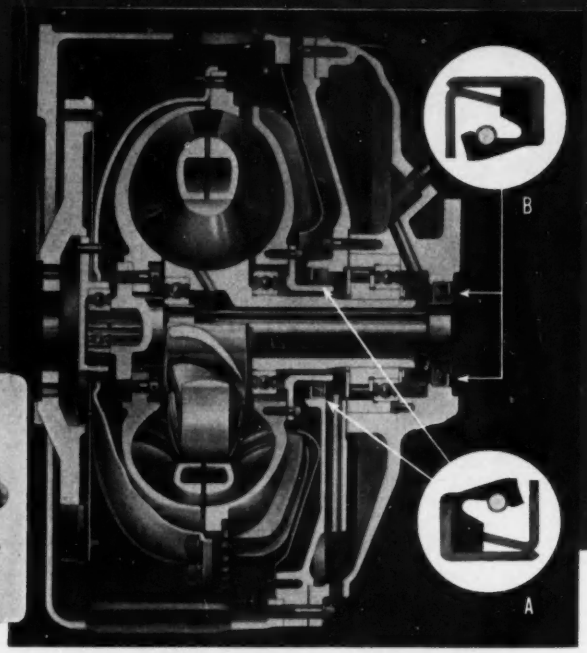
PERSONNEL HEATING
ENGINE AND EQUIPMENT PRE-HEATING
WINDSHIELD DEFROSTING

Small orders...
Large orders...
you can depend on the...
top 10 SOURCES for Mechanical Springs
Divisions of Associated Spring Corporation and Canadian Affiliate
WALLACE BARNES COMPANY
Bristol, Connecticut
THE WILLIAM D. GIBSON COMPANY
1800 Clybourn Avenue
Chicago 14
RAYMOND MANUFACTURING CO.
Corry, Pennsylvania
BARNES-GIBSON-RAYMOND
40300 Plymouth Rd.
Plymouth, Mich.
B-G-R COOK PLANT
Ann Arbor, Michigan
F. N. MANROSS AND SONS CO.
Bristol, Connecticut
OHIO DIV.
Associated Spring Corporation
1712 East First Street
Dayton, Ohio
DUNBAR BROS. COMPANY
Bristol, Connecticut
MILWAUKEE DIV.
Associated Spring Corporation
241 East Erie Street
Milwaukee, Wisconsin
THE WALLACE BARNES COMPANY LTD.
Hamilton, Ont., Canada

C/R

THE SEAL OF COOPERATIVE RESEARCH

Fuller TRANSMISSIONS



ON ROAD OR RAIL, FULLER TORQUE CONVERTERS PROVIDE POSITIVE ASSURANCE OF DEPENDABILITY

Today, you'll find Fuller torque converters in milk delivery trucks, fork-lift trucks, tow trucks, hoists, gasoline locomotives and in other applications where fluid transmission of power and positive assurance of dependability are absolute necessities. The 50-year-old Fuller Manufacturing Company has chosen C/R Sirvene "Perfect" oil seals to insure this vital dependability.

The illustrations show how these custom-designed C/R shaft-type seals provide positive bearing protection for the Fuller torque converter used in the two-speed forward and one-speed reverse transmission of International LB-140 milk delivery truck. A special C/R Sirvene seal at location "A" holds the oil within the circuit under pressures of from 10 to 12 pounds p.s.i. At location "B" a similar design of seal insures against leakage from the fluid coupling.

Solving tough or unusual sealing problems is C/R's specialty. That's why more automobiles, more agricultural equipment and industrial machines are relying on C/R seals than any other sealing device.

P.S. For immediate delivery, C/R "Perfect" oil seals are stocked in over 1800 sizes covering 15 different types.

CHICAGO RAWHIDE MANUFACTURING CO.

1309 Elston Avenue **OIL SEAL DIVISION** Chicago 22, Illinois

The cooperative research and engineering services which C/R has provided in producing special C/R oil seals (both synthetic rubber and leather) for leading manufacturers are available to you. We will be pleased to send you any information you wish. Brochure on request.

C/R PERFECT Oil Seals

sirvis

Mechanical Leather Products

Ilonix diaphragms, packings and other products give dependable service under difficult operating conditions.

SIRVENE

The Scientifically Compounded Elastomer

Custom-engineered and custom-built for critical service in aircraft, automotive and other mechanisms.

Representatives in these Principal Cities

Boston • New York • Syracuse
Philadelphia • Pittsburgh • Cincinnati
Cleveland • Detroit • Peoria
Minneapolis • Kansas City • Houston
Los Angeles • San Francisco

FOR YOUR HEAVY DUTY CLUTCHES

Wherever operating conditions are extremely severe, and dependable clutch and brake performance of major importance . . . that's where cost-conscious engineers specify Velvetouch. Because all-metal Velvetouch clutch plates, facings and brake linings are designed for heavy duty use! They last longer . . . won't glaze like asbestos . . . require fewer adjustments . . . deliver a uniform friction action. And by merely changing the proportions of the powdered metals used in making Velvetouch . . . a friction surface can be developed to meet your individual requirements. Let us help you. Either contact our nearest branch . . . or write The S. K. Wellman Co., 1374 E. 51st St., Cleveland 3, Ohio

Velvetouch

THE S. K. WELLMAN CO. WAREHOUSING CENTERS

ATLANTA—119 14th St., N. E. Atlanta 5, Georgia

CHICAGO—1500 South Western Ave., Chicago 8, Illinois

CLEVELAND—1392 East 51st St., Cleveland 3, Ohio

DALLAS—3407 Main Street, Dallas 1, Texas

LOS ANGELES—1110 S. Hope Street, Los Angeles 15, Calif.

PHILADELPHIA—1545 West Belfield Ave., Philadelphia, Pa.

PORTLAND—636 N. W. 18th Ave., Portland 9, Oregon

SAN FRANCISCO—424 Bryant Street, San Francisco 7, Calif.

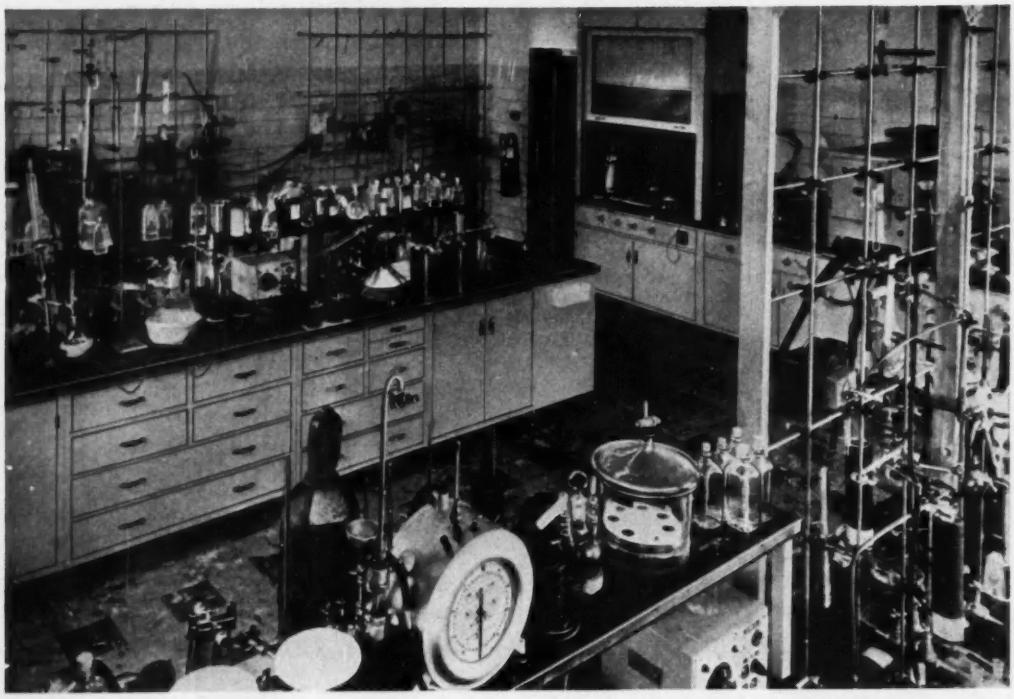
TORONTO, ONTARIO The S. K. Wellman Co. of Canada, Ltd., 2839 Dufferin St.

• • •

EXPORT DEPARTMENT—8 So. Michigan Ave. Chicago 3, Ill., U. S. A.

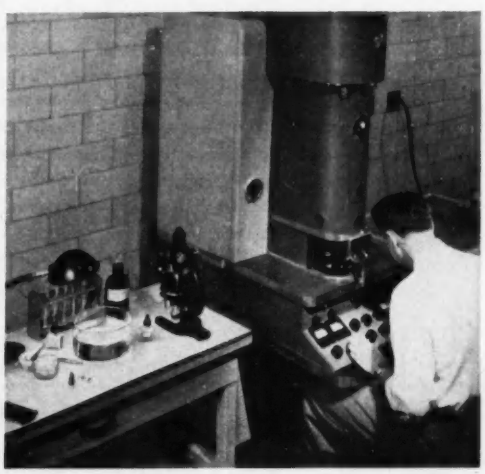
WASHINGTON OFFICE—1101 Vermont Ave., N. W. Washington 5, D. C.

These Great Laboratory



PETROCHEMICALS offer independent inventors great opportunity for exploration and reward. Such synthetics as Nylon, Vinylite, Neolite are already indispensable to our expanding economy—and new ideas in this area are at a premium today.

UNDER THE SINCLAIR PLAN, chemistry laboratories like these are open for the first time to independent inventors.



ELECTRON MICROSCOPE, capable of magnifying 100,000 times, is typical of the expensive equipment now available.

Facilities Are Open to You

Many inventive people have responded to the Sinclair Plan's offer of laboratory facilities — to others who wish to do so, a suggestion: There is promise and profit in oil-based synthetics.

EIGHT months ago, Sinclair turned over a part of its great laboratories at Harvey, Illinois, to independent inventors who had promising ideas in the field of petroleum products but who did not have the facilities needed to develop or prove out their ideas.

To date nearly 5,000 people have submitted ideas to the laboratories, and the Plan is recognized as a valuable service to independent inventors. As a result we have made the Sinclair Plan part and parcel of the long-range operation of our company.

There may be inventive people interested in this Plan but wondering what sort of ideas or what areas would be profitable to explore. To those people we suggest the field of petrochemicals. Such things as plastics, synthetics, substitutes and new materials as yet undeveloped—made from petroleum—offer great opportunities for invention and reward.

If you have an idea of this sort—or in the general area of petroleum products or applications—you are invited to submit it to the Sinclair Research Laboratories. In your own interest, each idea must first be protected by a patent application or a patent.

The inventor's idea remains his own property

If the laboratories select your idea, they will make a very simple arrangement with you: In return for the laboratories' work, Sinclair will receive the privilege of using the idea for its own companies, free from royalties.

This agreement in no way hinders the inventor from selling his idea to any of the hundreds of other oil companies for whatever he can get. Sinclair has no control over the inventor's sale of his idea to others, and has no participation in any of the inventor's profits.

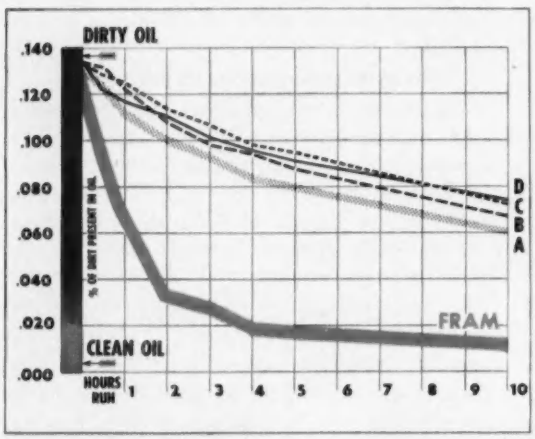
HOW TO PARTICIPATE: Instructions are contained in an Inventor's Booklet available on request. Write to: W. M. Flowers, Executive Vice-President, Sinclair Research Laboratories, Inc., 600 Fifth Avenue, New York 20, N. Y.

IMPORTANT: *Please do not send in any ideas until you have sent for and received the instructions.*

SINCLAIR RESEARCH LABORATORIES—nine buildings containing the most modern testing equipment known—have contributed many of today's most important developments in petroleum. Under the Sinclair Plan, the available capacity of these great laboratories is being turned over to work on the promising ideas of independent inventors everywhere.

SINCLAIR—for Progress

Here's PROOF that FRAM FILTERS BEST



Controlled Laboratory tests show FRAM cartridges remove more contaminants faster than other popular brands

In a series of oil filtration laboratory tests, the Fram Filcron cartridge was tested against other popular cartridges of comparable size. Batch clean-up tests were performed using identical quantities of oil containing identical quantities of contaminants (.134% by weight under electric eye analysis). Tests were run for 10 hours, with the results graphed at the left. It is interesting to note that at the end of *5 hours*, the Fram Filcron had removed more than half again as much contaminant as other cartridges did at the end of *10 hours!*

You are invited to make full use of FRAM's facilities to solve your filtration problems

In Dexter, Michigan, Fram Corporation operates the world's first large Dust Tunnel. Here, all types of internal combustion powered equipment can be tested under any simulated dust condition—accurately measured and controlled! Vehicles from giant buses to small cars can be tested in hours instead of weeks. Dust conditions from city air to a blinding sand storm can be duplicated at will. These facilities are at your disposal . . . for the asking! If you'd like to use Fram's Dust Tunnel to solve your filtration problems, write:

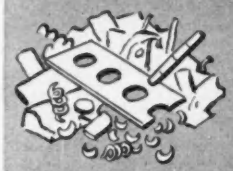
FRAM CORPORATION, Providence 16, R. I.
In Canada: J. C. Adams Co., Ltd., Toronto, Ontario

Manufacturers of...

FRAM OIL & MOTOR CLEANERS ★ FRAM FILCRON REPLACEMENT CARTRIDGES ★ FRAM CEL-PAK REPLACEMENT CARTRIDGES FRAM FILTRONIC REPLACEMENT CARTRIDGES ★ FRAM CARBURETOR AIR FILTERS ★ FRAM GASOLINE FILTERS ★ FRAM CRANKCASE AIR FILTERS ★ FRAM POSITIVE CRANKCASE VENTILATORS ★ FRAM RADIATOR & WATER CLEANERS ★ FRAM FUEL OIL FILTERS ★ FRAM INDUSTRIAL OIL AND FUEL FILTERS ★ FRAM SEPARATOR-FILTER FOR IMMISCIBLE LIQUIDS ★ FRAM CUSTOM-DESIGNED FILTERS FOR SPECIALIZED APPLICATIONS.

FRAM
OIL • AIR • FUEL • WATER
FILTERS

HOW THE *SCRAP* THAT JACK MADE —MADE JACK *AND MORE*



This is the Scrap that Jack made.

This is the Man who found the Scrap that Jack made.

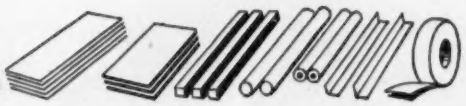
This is the Clerk who was called by the Man who found the Scrap that Jack made.

This is the Dealer who dealt with the Clerk who was called by the Man who found the Scrap that Jack made.

AND TO MAKE THE STORY SHORTER:

This is the jack the dealer paid for the Scrap that Jack made.

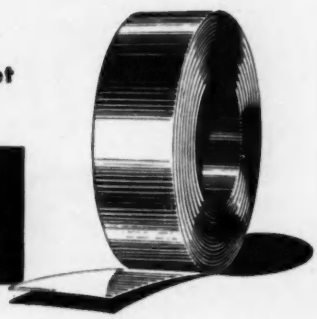
AND THIS IS THE STEEL THAT INDUSTRY GETS



from the Scrap that Jack made!

MORAL:

Check your Plant for Scrap Today and Get it Moving—*That* Pays Everybody!



Superior Steel
CORPORATION
CARNEGIE, PENNSYLVANIA

"customer conscious..."

You are treated like a customer when you deal with The Bunting Brass & Bronze Company. It is a tradition in the Bunting organization to consider the good will of the customer as the most important factor in the transaction. Bunting customers find that Bunting resourcefulness no less than Bunting products, is made available when needed . . . Ask any Bunting customer.

The sleeve bearing is not complex in struc-
ture; it conforms readily to design requirements;
it is easily installed. Cast Bearing Bronze is the
most adaptable of all sleeve bearing materials;
it possesses excellent anti-friction properties.
With proper film lubrication, its coefficient of fric-
tion is as low as can be obtained with any
other bearing type. A successful Bunting Bronze
bearing installation is readily attainable. We
ask the opportunity to work with you, and to
quote on your requirements.

Bunting

BRONZE BEARINGS • PRECISION BRONZE BARS • BUSHINGS

THE BUNTING BRASS & BRONZE COMPANY • TOLEDO 1, OHIO • BRANCHES IN PRINCIPAL CITIES

Cummins Diesels
do so many jobs-so much better

Shovels, cranes, industrial locomotives

Drilling rigs, centrifugal pumps, generator sets

Buses and on-highway trucks

...because they're custom-built to fit the job

Earthmovers, logging yarders and loaders

Off-highway trucks, crawler tractors

Work boats, pleasure craft

Lightweight, high-speed Diesels (50-550 hp) for these and many other uses

---

...because they're

BUILT NOT ONCE BUT TWICE

Rugged, lightweight, high-speed Cummins Diesels are at work everywhere. Each engine is built *twice*. It's assembled, run-in tested, disassembled and inspected, then reassembled and tested again. This extra care in building, plus Cummins exclusive fuel system and an efficient and expanding service and parts organization, means minimum "down time", more power and profits for the user. See your Cummins dealer.

CUMMINS Diesel

TRADEMARK REG. U. S. PAT. OFF.

Diesel power by CUMMINS

CUMMINS ENGINE COMPANY, INC., COLUMBUS, INDIANA

Export: Cummins Diesel Export Corporation • Columbus, Indiana, U.S.A. • Cable: Cumdiex

Put FORCE behind your vibration testing

...more than 2500 pounds of it with this big MB exciter

POWER AND ENDURANCE feature this new MB Model C25 Vibration Exciter – today's largest and most dependable electromagnetic shaker.

It has already proved its heavy-duty capacity in a number of important military vibration testing applications. In frequencies from 3 to 500 cps, it easily develops required forces to produce accelerations of 15g with 100 lb table load or 20g with 60 lb table load, for example.

Like all MB Exciters, Model C25 Shaker provides easy, accurate, continuous control of force and frequency. It allows "scanning" for response to vibration of parts under test. Electrically interlocking controls assure trouble-free operation. Automatic cycling control available to meet specifications of MIL-E-5272.

Vibration testing shakes out troubles before they start. It's not only a "must" for much military equipment, but also a good idea for *any* product. If you'd like to know more about it, why not contact "headquarters" for vibration engineering – MB! You'll find the help and advice you're seeking.

APPROVED MOUNT FOR ISOLATING VIBRATION

This Type 17 MB Vibration Isolator incorporates a principle first achieved by MB in mountings. It has equal spring rates in all directions in order to isolate all modes of motion with equal efficiency. Available for loads from 0.5 to 100 lbs to meet MIL-I-5432 (AN-I-16a) specification on vibration isolation. Write Dept. 7 for details.

MORE DETAILS

New bulletin containing specifications, operational information and helpful hints on usage, is now available on the complete line of MB Vibration Exciters which includes models from 10 lbs to 2500 lbs force output. Ask for **Bulletin No. I-VE-7.**

THE MB MANUFACTURING COMPANY, INC.
1060 STATE STREET, NEW HAVEN 11, CONN.

PRODUCTS AND EQUIPMENT TO CONTROL VIBRATION . . . TO MEASURE IT . . . TO REPRODUCE IT

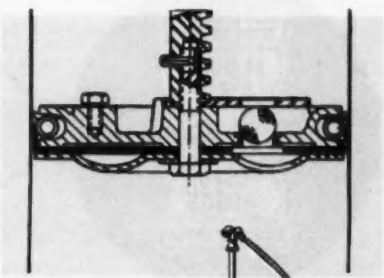
Are these two Cup Packings *Different*?

Yes... and HOW!

The leather cup packing on the left leaked gasoline. The *right* one does *not*.

A manufacturer of gallon stroke pumps for gasoline and oil dispensing employs a leather cup packing on the piston head as shown in the sectional drawing.

The ordinary cup leather did not deliver correct measure because of leakage through the leather. The complete pump assembly was shipped to G&K-INTERNATIONAL for suggestions. Because of the many thousands of pumps already in the field, redesign or improvement in the cup packing without change of the assembly was indicated.



and HOW! G&K-INTERNATIONAL developed a special leather treatment to completely prevent the passage of gasoline through the leather cup packing without changing its flexibility or other requisite characteristics. With these cups installed, the company now reports that the pumps deliver accurate measurement to their complete satisfaction.

Be sure you get the correct type of packing made from the proper components for your work! Send us complete specifications of your packings needs and G&K-INTERNATIONAL Engineers will help you solve your packings problems—before trouble starts.

second century G and K – INTERNATIONAL

GRATON & KNIGHT ESTAB. 1851

Leather and synthetic packings

GRATON & KNIGHT COMPANY
Worcester 4, Mass.

INTERNATIONAL PACKINGS CORPORATION
Bristol, New Hampshire

McQUAY-NORRIS

PISTON RINGS

TIME TESTED
McQUAY NORRIS
PISTON RINGS
PROVEN IN SERVICE

Tried, and proved for over 40 years, the performance of McQuay-Norris piston rings is assured...and they are specifically engineered to meet every requirement, no matter how exacting.

McQUAY-NORRIS MANUFACTURING CO.
ST. LOUIS 10, MO.

Many Engineers have not yet heard the good news:

...LOCKHEED IN CALIFORNIA HAS RAISED ENGINEERS' SALARIES

Lockheed Aircraft Corporation has raised engineers' salaries recently, in recognition of the importance and excellence of their work on both military and commercial aircraft.

The substantial increases make Lockheed engineers among the highest paid in the aircraft industry.

Engineers who join the Lockheed staff receive the benefits of these pay boosts.

In addition to increased salaries, Lockheed also offers engineers:

1. A "bonus" every day in better living—just because you live in Southern California, in an area where the climate is beyond compare.

2. A future that offers both security and advancement, helping create planes for defense, planes for the world's airlines in Lockheed's long-range development program.

3. Better *personal* working conditions among men who have built a reputation for leadership in aviation.

immediate openings for:

Aerodynamicists
Aerodynamics Engineers
Aircraft Design Engineers
Aircraft Electrical and Radio Designers
Airplane Specifications Engineers
Armament Engineers
Design Engineers—Lockheed will train you to be an aircraft engineer. Full pay while training.
Drawing Checkers
Electronics Engineers
Engineering Technical Writers
Estimators—Plant Facilities and Equipment
Flight Manuals Engineers
Machine and Equipment Design Engineers
Manufacturing Engineers
Manufacturing Research Engineers
Production Design Engineers
Senior Electronics Systems Engineers. M.S. or Ph. D. in Electrical Engineering or Physics
Stress Engineers and Analysts
Thermodynamicists
Thermodynamics Engineers
Tool Standards Engineers
Weight Engineers
Also...Technical Editor to write and review technical reports
Sales Engineer with airline experience
Recent Engineering Graduates

To Engineers with Families:

Housing conditions are excellent in the Los Angeles area. More than 40,000 rental units are available in the Los Angeles area. Huge tracts for home ownership are under construction now. Thousands of homes have been built since the last war. Lockheed counselors help you get settled.

Lockheed also offers these extra benefits:

Generous Travel allowances • Outstanding Retirement Plan • Vacations with pay • Low cost group life, health, accident insurance • Sick Leave with pay • Credit Union, for savings and low-cost financing • Employees' Recreation Clubs • Regular performance reviews, to give you every opportunity for promotion • On-the-job training or special courses of instruction when needed.

Send today for illustrated brochure describing life and work at Lockheed in Southern California. Use this handy coupon.

ENGINEER TRAINING PROGRAM
Mr. M. V. Mattson, Employment Mgr. Dept. SAE-4

Lockheed AIRCRAFT CORPORATION
Burbank, California

Dear Sir: Please send me your brochure describing life and work at Lockheed.

My Name _____

My Field of Engineering _____

My Street Address _____

My City and State _____

short order
or FULL COURSE

We can meet your most exacting requirements for custom quality engine bearings in small runs or mass-production quantities.

Our exacting production techniques have been developed over the years to cope with today's fluctuating demands for automotive, tractor and industrial engines.

When you specify our engine bearings you gain the "know-how" of more than 25 years of precision experience in the manufacture of the finest engine bearings.

DETROIT ALUMINUM & BRASS CORPORATION

DETROIT 11, MICHIGAN

IF you want the last word on Eddy-Current Couplings, write for your copy of this booklet

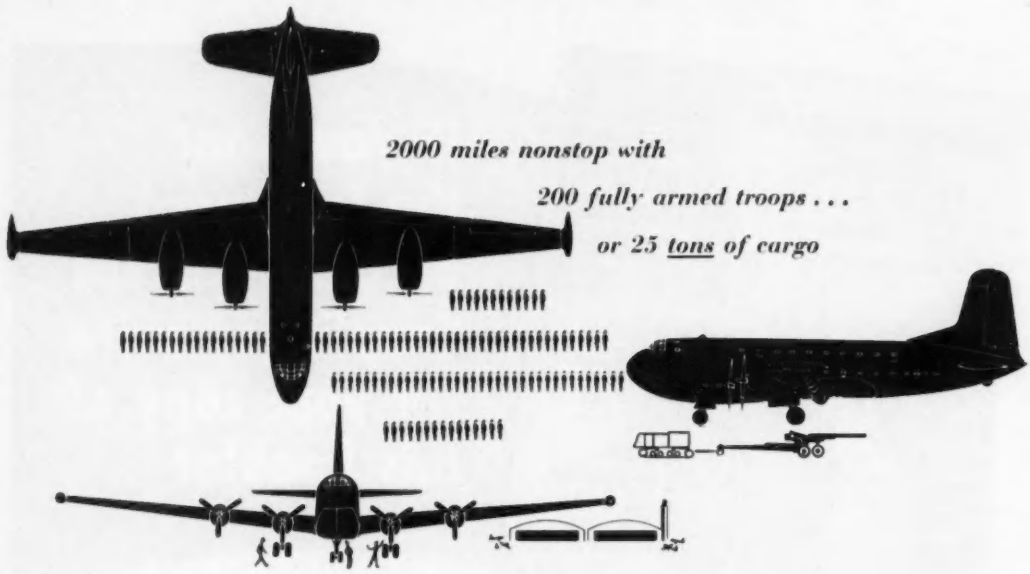
Eddy-Current Couplings provide a long list of desirable characteristics including instantaneous response, infinitely adjustable speed control, wide speed range, quiet operation, low power losses, low maintenance cost—without mechanical contact between the driving and driven members—and entirely from AC power.

If you are interested in this modern method of speed control, write on your company stationery for this comprehensive booklet. It presents a down-to-earth explanation of the Eddy-Current Principle, and the operation of the Dynamatic Eddy-Current Water-Cooled Coupling.

DYNAMATIC® CORPORATION • KENOSHA WISCONSIN

Subsidiary of EATON MANUFACTURING COMPANY, Cleveland, Ohio

Dynamometers • Oil Well Draw-Works Brakes • Adjustable-Speed Couplings • Eddy-Current Brakes
Ajusto-Spedes • Shovel Clutches • Press Drives • Lift Truck Clutches • Electronic Controls



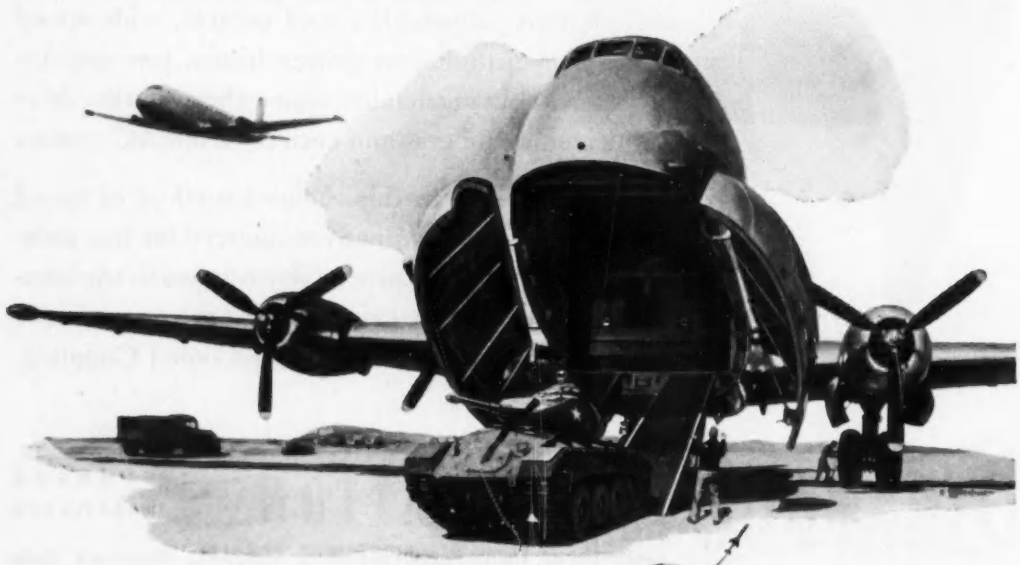
—the Douglas C-124 Globemaster!

Most versatile troop and cargo carrier in the air today, the Douglas Globemaster gives our Armed Forces new mobility in either attack or defense.

Designed to take off at a gross weight of more than 87 tons, the Globemaster II —in flight tests—exceeded planned capacity by nearly 18 tons. This aerial giant can lift 94% of all types of military vehicles fully assembled . . . tanks, bulldozers, huge cranes and loaded trucks.

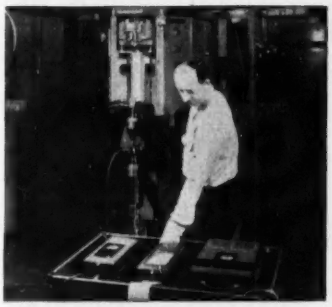
A single C-124 can transport 200 completely equipped troops across the Atlantic and land with generous fuel reserves. When used as an airborne hospital, it can accommodate 127 litter patients . . . plus all of the necessary doctors, nurses and attendants.

Performance of the C-124 Globemaster is another example of Douglas leadership in aviation. Building planes that can be mass-produced to fly *faster and farther with a bigger payload* is always the basic rule of Douglas design.



Depend on *DOUGLAS* **First in Aviation**

HOW'S THE SURFACE? The Brush Surface Analyzer® shows average roughness in micro-inches . . . and provides you with a chart showing the irregularities making up this average. This chart is a highly magnified profile of the surface, enlarged beyond the range of optical microscopes. Variations of less than 1/1,000,000 of an inch are readily apparent, and can be measured on the calibrated chart. Analyzer shown is at Commercial Centerless Grinding Co., Cleveland, Ohio.



HOW'S THE TIMING? This Brush Analyzer consisting of a-c amplifier, d-c amplifier and direct-writing oscillograph is used by Taylor-Winfield Corporation to check the current and timing calibration of each spot welder before shipment. By observing wave shapes the inspectors calibrate controls quickly and accurately.

WHAT'S YOUR PROBLEM? Brush Analyzers simplify a host of design and production studies. Here, one is used by engineers of The Marion Power Shovel Company to get design facts from excavators in actual operation.

For bulletins describing Brush instruments shown above, write The Brush Development Company, Dept. C-25, 3405 Perkins Ave., Cleveland 14, Ohio.

Measuring and recording engine torque.

Save plotting and testing time with a BRUSH analyzer

You can record static or dynamic phenomena instantaneously and accurately . . . test parts and structures under actual operation . . . with the Brush Strain Analyzer. Engineers throughout Industry are discovering important time savings with this Brush electronic instrument. It eliminates many testing and plotting operations in the study of torque, strain, vibration, pressure and other variables. Its direct-writing oscillograph provides a permanent record of the test.

The Brush Strain Analyzer is a rugged, portable tool. It can be used anywhere . . . in the laboratory, on the test floor or in the field, wherever the job requires.

Find out how this versatile Analyzer can help solve your problems and save your time! Brush representatives are located throughout the U. S. In Canada: A. C. Wickman Ltd., Box 9, Station N, Toronto.

Put it in writing with a Brush Recording Analyzer

For catalog describing Brush instruments and their application, write The Brush Development Co., Dept N-25, 3405 Perkins Ave., Cleveland 14, Ohio.

BRUSH

THE *Brush* DEVELOPMENT COMPANY

PIEZOELECTRIC CRYSTALS AND CERAMICS • MAGNETIC RECORDING

ACOUSTIC DEVICES • ULTRASONICS • INDUSTRIAL & RESEARCH INSTRUMENTS

THE CHOICE

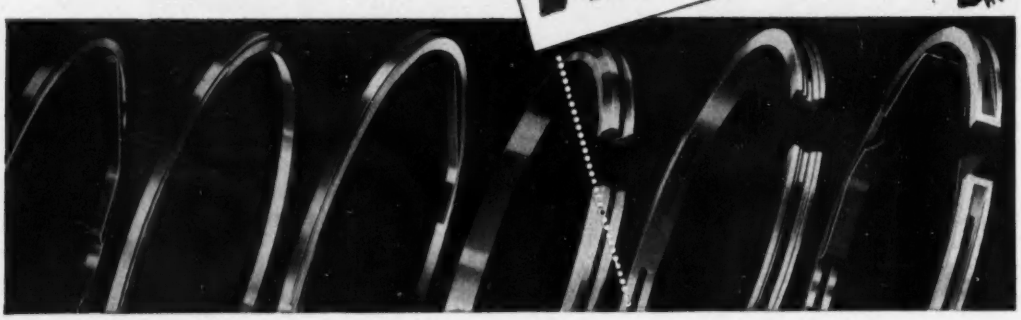
OF OVER 60 LEADING ENGINE BUILDERS!

When WAUSAU engineers or produces piston rings for you, we draw upon an exceptionally rich and varied background. For WAUSAU has supplied original equipment and service rings, over a period of 25 years, to more than 60 prominent builders of gasoline and Diesel engines. We invite you to consult us on any piston ring problem you may have.

VALVE SEATS, too, are a WAUSAU specialty! We have developed them for nearly every application, and they include such types as specially alloyed cast iron, steel, bronze, and bi-metal corrosion-resistant.

WAUSAU MOTOR PARTS COMPANY
2200 HARRISON STREET • WAUSAU, WISCONSIN

WAUSAU



Reduce the use of critical alloys in gas turbine structures

N-A-X AC9115 ALLOY STEEL offers a means of reducing the use of critical alloy steels of the "stainless" type in gas turbine and similar applications. In specific cases it has replaced over half the amount of strategic material originally required, with no sacrifice of quality.

N-A-X AC9115 ALLOY STEEL has high strength and toughness values at temperatures ranging from −70° F. to +1,000° F. It can be readily cold formed into the most difficult shapes; its response to welding by any process is excellent. It must, however, be suitably coated for protection against cold or hot corrosion.

N-A-X AC9115 ALLOY STEEL is available in bars as well as flat rolled products. Investigate the outstanding properties and characteristics of this steel and, through its use, conserve the critical material so necessary to our nation.

with N-A-X AC9115

ALLOY STEEL

GREAT LAKES STEEL CORPORATION
N-A-X Alloy Division • Ecorse, Detroit 29, Michigan

NATIONAL STEEL CORPORATION

Complete
MOTOR TRANSPORT BRAKE SERVICE

Wherever you are . . . you are not far from a MIDLAND Distributor or Dealer •

YOU have two big advantages when your Motor Transport equipment has Midland Power Brakes.

You have the assurance that braking equipment is correctly engineered and sturdily built to give long, trouble-free service — been proved by billions of miles of use all over the world.

In addition, Midland's widespread distributor and dealer organization insures that parts and service are available *promptly* wherever your equipment may be.

For fine braking service, any way you look at it, specify Midland.

THE MIDLAND STEEL PRODUCTS CO.
6660 MT. ELLIOTT AVE. • DETROIT 11, MICH.
Export Department: 38 Pearl Street, New York, N. Y.

MIDLAND REPAIR KITS
Contain genuine parts necessary for a thorough rebuilt job.

MIDLAND INSTALLATION KITS
Contain all parts required for complete air or vacuum Power Brake installation on your truck, tractor or trailer.

FACTORY REBUILT EXCHANGE UNITS
Original equipment guarantee. Factory-rebuilt to operate like new units. Secure them through your nearest Midland distributor.

Those who *know* Power Brakes choose MIDLAND

MIDLAND

POWER BRAKE EQUIPMENT

AUTOMOBILE AND TRUCK FRAMES

BUS DOOR CONTROLS

250 Service Organizations To Serve You Wherever You Are

AROUND THE CLOCK AROUND THE WORLD

Tires that move the earth

Schrader—top tire valve manufacturer—actually produced the first working samples of large bore tire valves in cooperation with the tire industry. What started as an experimental development is now a complete, practical line of Schrader Products to help the industry move the earth.

A. SCHRADER'S SON, BROOKLYN 17, N. Y.
Division of Scovill Manufacturing Company, Incorporated

Giant earthmovers have changed the face of our country . . . building roads, laying foundations, even the mining of open-strip ore veins. These machines of progress are made possible and practical by the ingenuity of America's tire manufacturers. Vital to proper performance of these giant tires is the valve that *locks* the air in the tire.

Schrader
REG. U. S. PAT. OFF.

FIRST NAME IN TIRE VALVES
FOR ORIGINAL EQUIPMENT AND REPLACEMENT

FOR LOW-COST

TORQUE CONVERTER COOLING . . .

BY **YOUNG**

Trucks
Locomotives
Buses
Young torque converter cooler, Model TC-3, is compact, light in weight and ruggedly built for trouble-free service in any applications.
Military Vehicles
Stationary Engines
Earth Movers

Young-built fluid coolers were original equipment on some of the first torque converter installations, and have been thoroughly tested under actual operating conditions. Illustrated above is one of three types of coolers now in service on the nation's "big name" equipment. Their shell and tube bundle design means easier maintenance—longer, more efficient service without clogging. Check with Young Engineering Service on your specific requirements; Young standardized units pay-off in low-cost heat transfer.

1927 · 1952 — 25 YEARS OF PROGRESS IN HEAT TRANSFER ENGINEERING

YOUNG

Heat Transfer Products for Automotive and Industrial Applications.

Heating, Cooling, Air Conditioning Products for Home and Industry.

YOUNG RADIATOR COMPANY

Dept. 112-D • RACINE, WISCONSIN
Plants at Racine, Wisconsin and Mattoon, Illinois

COUPON BRINGS DETAILS ON YOUNG LOW-COST TORQUE CONVERTER COOLERS

YOUNG RADIATOR COMPANY
Dept. 112-D, Racine, Wis.

Please send me your catalog No. 1051 on Torque Converter Coolers.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

LOW-TEMPERATURE PROPERTIES OF FERROUS MATERIALS

AN SAE REPORT COVERING DESIGN, METALLURGICAL, AND FABRICATING PROBLEMS OF LOW-TEMPERATURE OPERATION

$2.00 per copy to SAE Members
$4.00 per copy to Non-Members

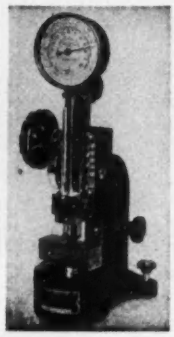
ORDER BLANK

Society of Automotive Engineers
29 West 39th Street
New York 18, N. Y.

Please send me ——— copies of SP-65 ("Low Temperature Properties of Ferrous Materials") Remittance is enclosed.

Name: .....

Address: .....



HARDNESS TESTING

Brinell—Shore—Scale

Included in our improved Portable Scleroscope Model D-1. This efficient single scale tester registers Brinell-Shore values without damage to the work. The old standby for thirty-five years.

WRITE FOR CIRCULAR

THE SHORE INSTRUMENT & MANUFACTURING CO., INC.

90-35 Van Wyck Expressway, Jamaica 2, N. Y.

The California Institute of Technology
JET PROPULSION LABORATORY
Pasadena, California

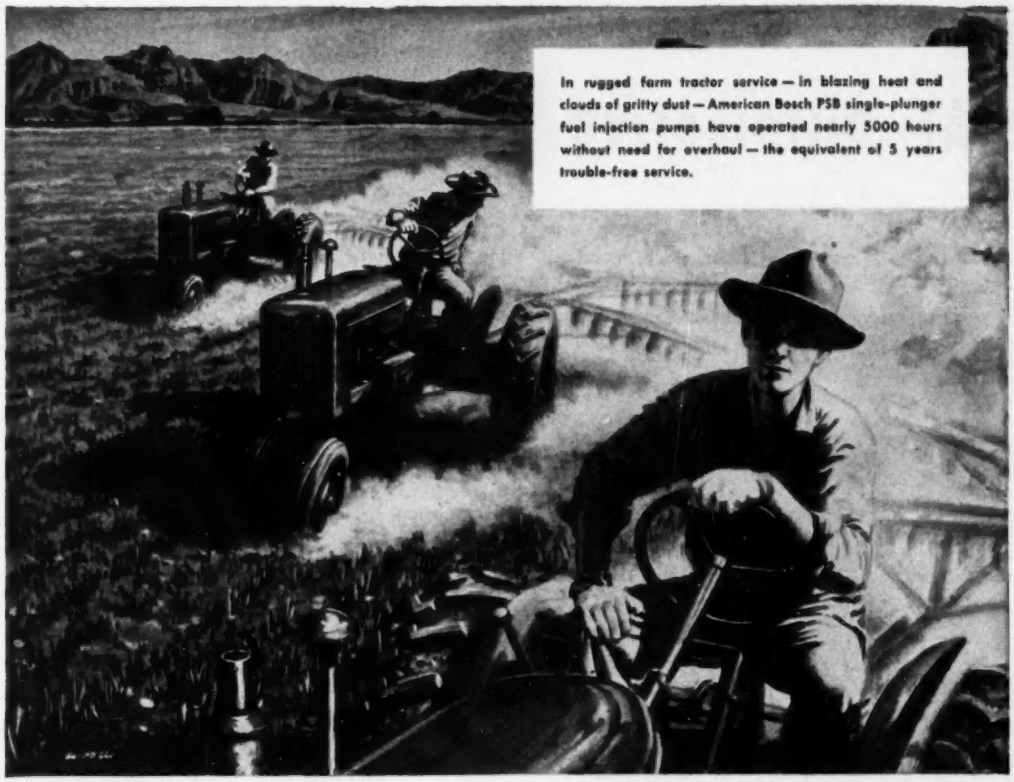
. . . has several openings in the following engineering fields:

Engineering Analysis
- Aerodynamics
- Aerodynamic Heating
- Heat Transfer
- Thermodynamics
- Dynamics
- Structural Studies
- Statistical Studies

Preliminary Design
Structural Design
Propulsion System Development
Test Engineers—Wind Tunnel
- Experienced in supersonic wind-tunnel tests desirable

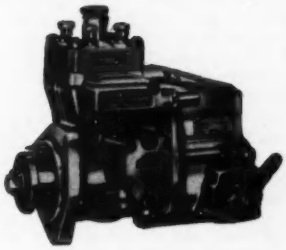
Excellent opportunity exists to learn all phases related to missiles, rockets and wind tunnel test operations. Apply giving details pertaining to academic background and work experience to

JET PROPULSION LABORATORY
4800 Oak Grove Drive — Pasadena 2, California


In rugged farm tractor service — in blazing heat and clouds of gritty dust — American Bosch PSB single-plunger fuel injection pumps have operated nearly 5000 hours without need for overhaul — the equivalent of 5 years trouble-free service.

PROVED ON THE TOUGHEST JOBS . . .

AMERICAN BOSCH *PSB fuel injection pump*



Tried and proved in the severest service, the American Bosch PSB single-plunger multi-cylinder fuel injection pump is expanding the use of economical Diesel power in fields where automotive-type Diesel engines are particularly adaptable.

Considerably smaller in size and weight than comparable multi-plunger types, the PSB pump uses only a single plunger to serve as many as six engine cylinders — can be more easily serviced in the field — reduces substantially the cost of injection equipment for small Diesel engines — has rolled up remarkable records of performance in severe service.

The engineering and production techniques that made possible the successful development of the single-plunger injection pump result from over 40 years experience of American Bosch in the design and manufacture of precision products — coupled with a strong research program that leads constantly to new and better contributions to the automotive, aviation and Diesel industries. American Bosch Corporation, Springfield 7, Mass.

AMERICAN BOSCH

SAE Automotive Drafting Standards

This newest SAE publication sets forth a unified drafting practice that will cut costs, time, and effort in the drafting room.

A section on Fundamentals includes forms . . . . lines . . . . lettering . . . . sectioning . . . . projection . . . . dimensioning . . . . . tolerances . . . . threads . . . . revisions . . . . and checking.

Additional special sections cover springs, surface finish, and chassis frames.

These standards are the product of the cooperative effort of scores of automotive engineers, experts on drafting requirements of leading companies - large and small - in the automotive industry.

Each page is punched ready for insertion in standard three-ring binder.

$3.00 EACH

QUANTITY PRICES ON REQUEST

3-RING BINDER - $2.00

ORDER BLANK

Society of Automotive Engineers
29 West 39th Street
New York 18, N.Y.

(Please add 3% sales tax for deliveries in New York City)

Please send me _____ copies of SAE AUTOMOTIVE DRAFTING STANDARDS (SP-66) as soon as they are available.

Send me _____ loose leaf binders.

_____ CHECK ENCLOSED

_____ Bill Company

_____ Bill Me

Name: _____

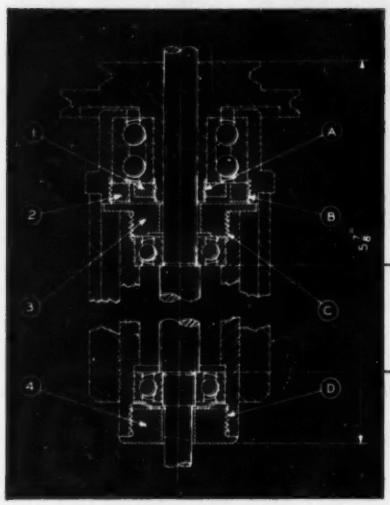
Company: _____

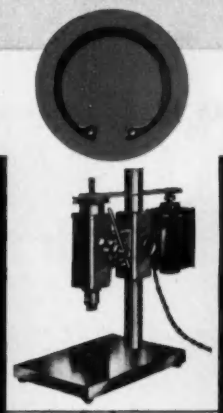
Company Address: _____

WALDES TRUARC RETAINING RINGS GIVE PRECISION FASTENING

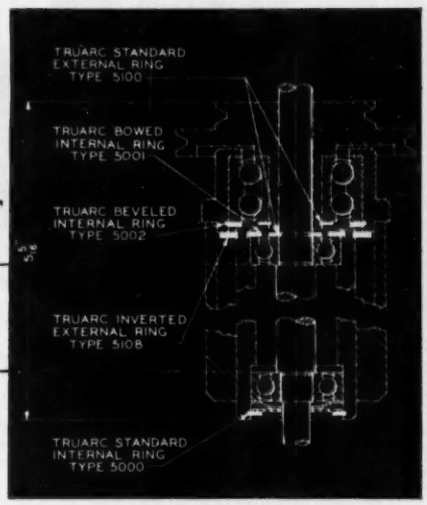
save $3.50 per unit in redesign of miniature Spindle Assembly

BEFORE. 4 threaded retainers required to hold parts of drill press assembly together. Machining of threads was slow, costly...required skilled labor. Threaded retainers took up much space.





AFTER. 6 Truarc Rings require only 6 simple grooves...lock parts firmly together for life of unit. Quick, easy to apply...no skilled labor needed. Length of spindle assembly cut 9/16".



In Philips & Hiss Company's new Miniature Drill Press, tolerances are critical . . . compactness, important. By using 6 Truarc Retaining Rings, they cut the length of the spindle assembly 9/16". The machine is more securely assembled, smaller, lighter. What's more—Truarc Rings eliminated threaded retainers and mating threads, saving 68 minutes of machining and skilled assembly time, or a saving of $3.50 per unit.

Redesign with Waldes Truarc Rings and you, too, will save on assembly time, improve product performance, facilitate easier servicing of whatever you make.

Wherever you use machined shoulders, bolts, snap rings, cotter pins, there's a Waldes Truarc Retaining Ring designed to do a better job of holding parts together. They're precision-engineered . . . quick and easy to assemble and disassemble. They give a never-failing grip, can be used over and over again.

Find out what Truarc Rings can do for you. Send your blueprints to Waldes Truarc engineers for individual attention, without obligation.

6 TRUARC RINGS (5 different types)
EACH SOLVED A SPECIAL PROBLEM

STANDARD EXTERNAL RING } forms secure shoulder, gives tight pressure fit when installed in a groove.
STANDARD INTERNAL RING }

INVERTED EXTERNAL RING
Provides uniform shoulder for curved abutting surfaces.

BOWED INTERNAL RING
Takes up end-play resiliently, accommodates accumulated tolerances.

BEVELED INTERNAL RING
Takes up end-play rigidly, remains secure against thrust and vibration.

SEND FOR NEW BULLETINS ➡

WALDES

TRUARC

REG. U. S. PAT. OFF.

RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS AND PLIERS ARE PROTECTED BY ONE OR MORE OF THE FOLLOWING U.S. PATENTS: 2,382,947; 2,382,948; 2,416,852; 2,420,921; 2,420,341; 2,439,705; 2,441,846; 2,455,189; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,308; 2,509,081 AND OTHER PATENTS PENDING.

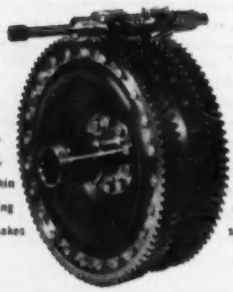
Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N. Y.
Please send engineering specifications and data on Waldes Truarc Retaining Ring types checked below. SA-0-

- ☐ Bulletin #5 Self-locking ring types
- ☐ Bulletin #6 Ring types for taking up end-play
- ☐ Bulletin #7 Ring types for radial assembly
- ☐ Bulletin #8 Basic type rings
- ☐ Send me information about the Waldes Grooving Tool.

Name_____
Title_____
Company_____
Business Address_____
City_____ Zone_____ State_____ 5678

YOUNG MEN OF VISION

Their business is precision! At Indiana Gear, success or failure is based on vision . . . today's gear problems were solved yesterday and tomorrow's "tough cogs" are on the boards today. It's a hard way to go, but they like it . . . because they fought their way to the top of a highly competitive business with master craftsmen, fine equipment, skilled sub-contractors and "young men of vision."



The thin steel ring gears, transmission set, round and true within carburizing, hardening control makes shown in this helicopter reduction are over 12" in diameter and are maintained .001" full indicator reading through and tempering. This absolute metallurgical subsequent tooth grinding unnecessary.

INDIANA GEAR

INDIANA GEAR WORKS • INDIANAPOLIS 7, INDIANA

KELSEY-HAYES

MOST ADVANCED *Feather Touch* PASSENGER CAR

POWER BRAKING

FOR EFFORTLESS, SAFER BRAKE CONTROL!

Right or Left Foot Braking!
BRAKE
THROTTLE
New accelerator-type low brake pedal operates the easiest and safest way imaginable!

. . . Thanks to Kelsey-Hayes Superior Vacdraulic Power

Kelsey-Hayes "Vacdraulic", already standard equipment on over 100,000 passenger cars made by one of the world's three largest automotive manufacturers, is today's most advanced power braking development.

Kelsey-Hayes "Vacdraulic" unit utilizes complete hydraulic control with a fixed reaction ratio which powers the brake action instantaneously, with a perfect "feather-touch" control, assuring perfect "pedal feel" in direct proportion to the pressure applied.

That's why more and more car manufacturers consider "Vacdraulic" the safest unit, particularly for passenger cars following the new trend to the much lower, faster, accelerator type of brake pedal.

(Have Kelsey-Hayes engineers give you convincing proof of "Vacdraulic's" superiorities)

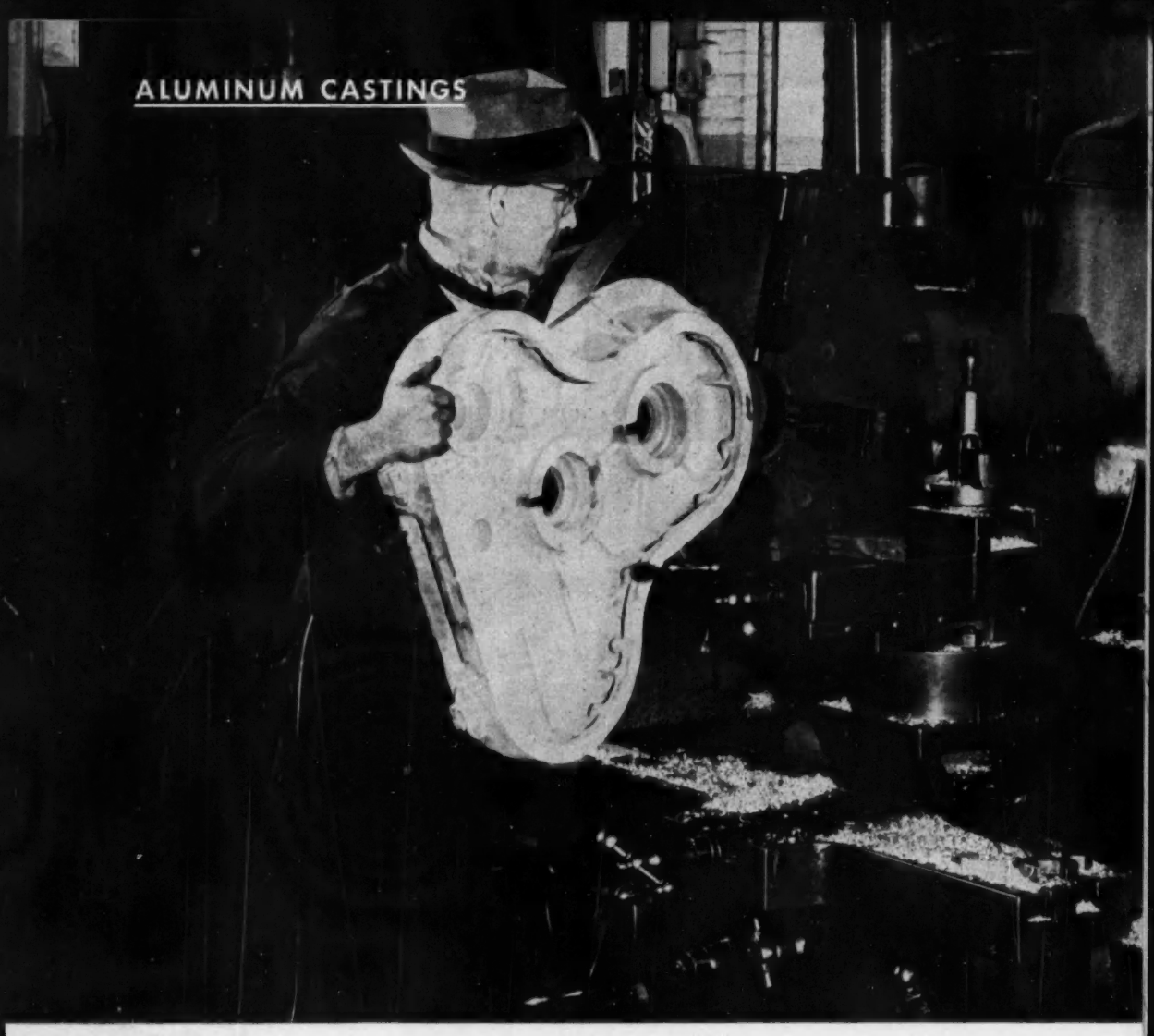
K-H ASSURES PROVEN PRODUCTS AT

KELSEY-HAYES WHEEL COMPANY

DETROIT 32, MICHIGAN

PRODUCTS: Wheels—Hub and Drum Assemblies—Brakes—Vacuum Brake Power Units—for Passenger Cars, Trucks, Buses—Electric Brakes for House Trailers and Light Commercial Trailers—Wheels, Hubs, Axles, Parts for Farm Implements.

PLANTS: Kelsey-Hayes Plants in Michigan (4); McKeesport, Pa.; Los Angeles, Calif.; Davenport, Iowa; Windsor, Ontario, Canada.



CASTINGS YOU CAN LIFT WITH EASE

ALCOA makes four kinds in aluminum—sand, plaster, permanent-mold and die

You don't have to look farther than your own shop to see the advantages of castings that weigh one-half, even two-thirds, less. Think how often castings are lifted while being machined, finished, assembled, and shipped. The savings in man power with aluminum castings are impressive.

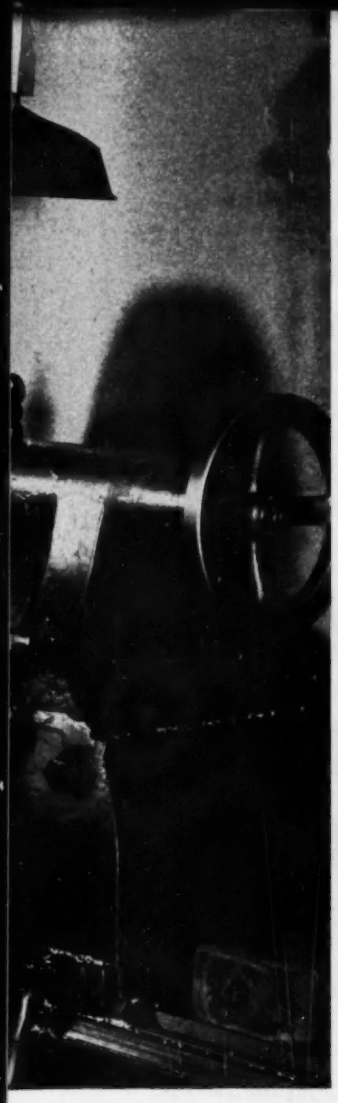
Look, too, at the other commercial advantages of Alcoa Castings. Ease of machining. Corrosion resistance. High conductivity of heat and electricity.

How about price? Alcoa Castings are competitive with castings of many other metals. Their cost, finished and assembled in your product, often amounts to surprising savings over heavy metals.

We have been making aluminum castings for 41 years. We have been working with aluminum for 64 years. To aluminum's natural advantages, we add the extra measure of sound and skillful design help. Any of our four foundries or two die-casting plants, located from coast to coast, are open for your inspection. Contact your local Alcoa Sales Engineer, listed under "Aluminum" in the classified phone book.

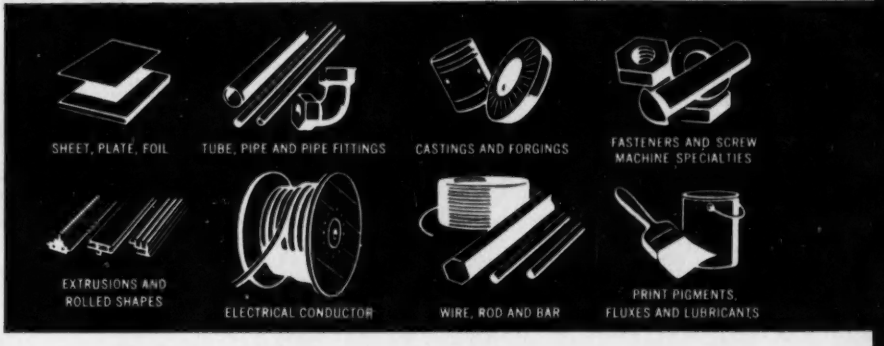
ALUMINUM COMPANY OF AMERICA
1904D Gulf Building • Pittsburgh 19, Pa.

ALCOA ALUMINUM ®



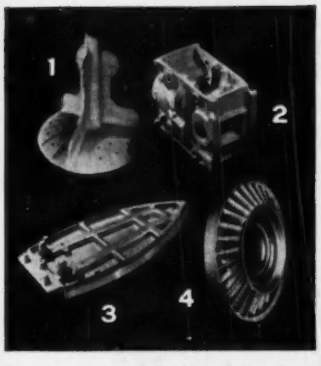
High production of permanent-mold castings in Alcoa's Cleveland foundry is illustrated by this automatic machine for making pistons.

Dimensional check of a completed die in Alcoa's die-casting plant at Chicago.



Remember, ALCOA makes "everything" in aluminum

While the sale of our products is limited by government regulations, you'll find no limitations on help in design, application, or fabrication.



Typical castings made by Alcoa. 1. Permanent-mold washing machine agitator. 2. Sand-cast machine part. 3. Die-cast electric iron soleplate. 4. Plaster-cast automotive torque converter.

Setting a die in a large die-casting machine at the Chicago plant.

A line of automatic molding machines, indicating the high production capacity for sand castings at Alcoa's Bridgeport, Conn., foundry.

SAE offers the...

SHOT PEENING MANUAL

SP-84

● A "HOW-TO-USE-IT" BOOK—
SAE Shot Peening Manual, the work of Division XX—Shot Peening, Iron & Steel Technical Committee, instructs engineers, designers, and shop men in shot peening "know how."

● A FIRST COMPLETE STORY—
the Manual fully discusses shot, shot peening machines, production procedures and process specifications; includes 29 illustrations and a bibliography of 50 selected references.

● A BRAND NEW SAE MANUAL—
the Shot Peening Manual—SP-84, newly listed with our publications, is priced at $1.50 per copy to SAE members and $3.00 per copy to nonmembers; quantity prices upon request.

ORDER BLANK

Society of Automotive Engineers
29 West 39th Street
New York, New York

Add 3% city sales tax for deliveries in N. Y. C.

Please send me . . . . copies of SP-84. (Check) (Cash) (Coupons)

Name _____

Company Name _____

Company Address _____

Engineered FOR EFFICIENT PERFORMANCE

Milsco MILWAUKEE

CUSHION SEATS* WITH MANY NEW FEATURES

NO. 1783 DELUXE CUSHION SEAT

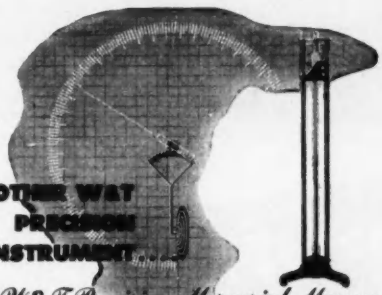
Milsco means comfort . . . more man-power . . . more work-power. This Deluxe Cushion seat is engineered for all types of heavy duty equipment . . . for rough and tough going . . . with built-in body-ease and back support. Padded seat with four inches of foam rubber; two inches of foam rubber on back and side walls. Genuine black leather covering. Safety side handles; two easy-to-attach bolts. Many other models.

Our 26th Year

★ GENUINE LEATHER WITH FOAM RUBBER

MILSCO MANUFACTURING CO., 2758 N. 33rd St., Milwaukee 45, Wis.

A-81



ANOTHER W&T PRECISION INSTRUMENT

The W&T Precision Mercurial Manometer

The W&T Precision Mercurial Manometer couples maximum precision with ease in handling. These two features have made it a leading instrument in modern research and manufacture for such uses as measuring sample pressures in infrared spectroscopy and calibrating aircraft altimeters. Because of its flexibility and accuracy, the Manometer can be used for almost any type of pressure measuring problem in the range of two atmospheres.

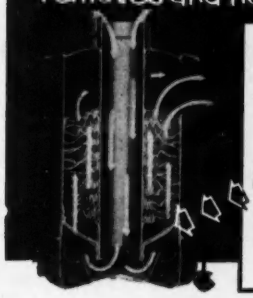
Such characteristics are only part of the picture. Take a look at these additional features:

1. Float type indicator eliminates difficulty in reading meniscus.
2. Adjusting knob provides for temperature compensation over a range of 30° C.
3. Precision bore manometer tube provides accuracy with interchangeability
4. Fixed cistern type manometer requires only one reading.
5. Mercury sealed valve permits evacuating the tube simply and easily at the point of use.
6. Flexible design permits measurement of absolute pressure, gauge pressure, differential pressure, and vacuum.

For more details, write today for free technical bulletin TP-29-A.

WALLACE & TIERNAN
PRODUCTS, INC.
ELECTRICAL MECHANISMS AND PRECISION INSTRUMENTS
Belleville 9, New Jersey • Represented in Principal Cities

New Tray-Type AIR CLEANER
removes and holds more dirt!



RECOMMENDED FOR HIGH-CAPACITY ENGINES on large tractors, rock crushers, power shovels, etc. Large dirt-holding capacity allows longer interval between servicing.

REMOVABLE TRAY SIMPLIFIES SERVICING. Entire tray is quickly removed for cleaning. Multiple screens prevent clogging of condensing element.

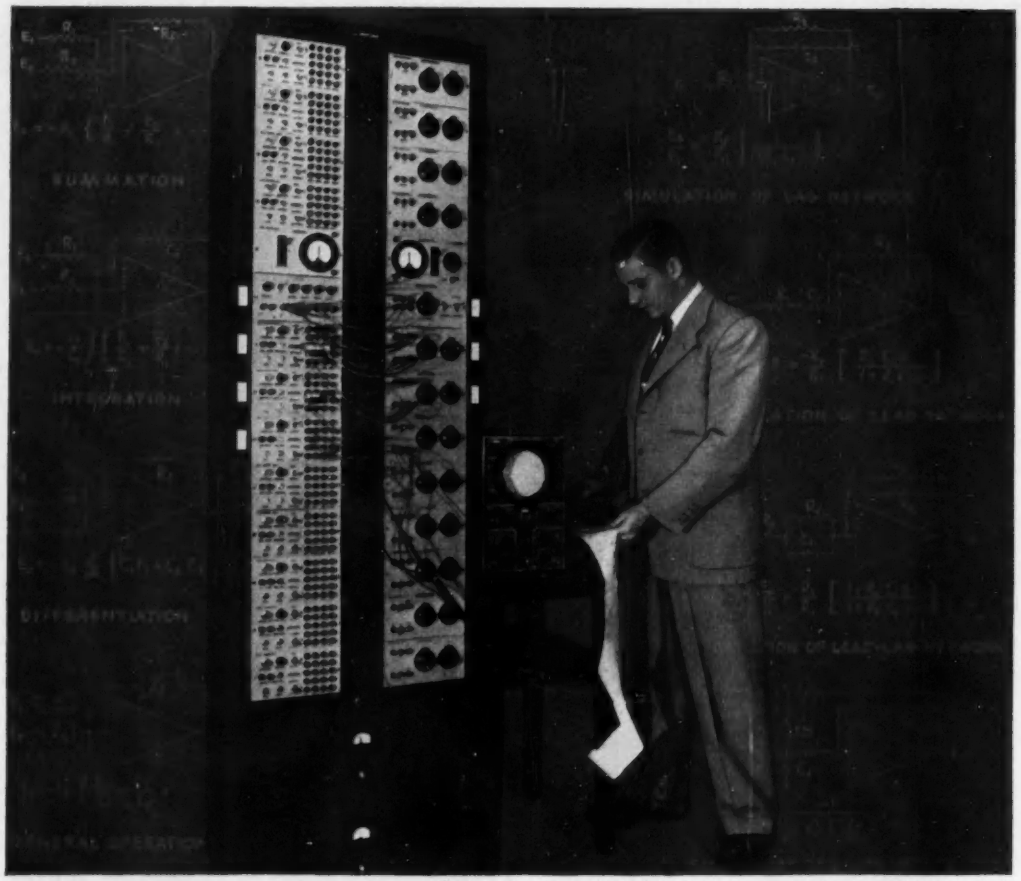
IN THIS NEW Donaldson heavy-duty cleaner, the removable multi-screen "tray" and revised oil cup design feeds more of the condensed oil back into the air stream adjacent to the center tube.

A balanced distribution of oil across the entire lower element has been achieved, eliminating both overloaded and "thin" areas.

Extensive tests in the field over a period of five years prove conclusively that the new cleaner has a higher efficiency and a greater dirt-holding capacity. We invite manufacturers to write or call for design data and test reports.

DONALDSON CO., INC. 666 Pelham Blvd., St. Paul 4, Minnesota
Donaldson Co. Ltd. (Can.), Chatham, Ont.

Donaldson AIR CLEANERS



Solving a dynamics problem with the Boeing Computer; oscilloscope at right shows result.

What's it like to be a Boeing engineer?

Boeing engineers enjoy many advantages — among them the finest research facilities in the industry. These include such advanced aids as the Boeing-designed, Boeing-built Electronic Analog Computer shown above.

This is part of the stimulating background that helps Boeing men maintain the leadership and prestige of an Engineering Division that's been growing steadily for 35 years.

If you measure up to Boeing standards, you can share that prestige. And you'll work with renowned engineers on such vital projects as guided missiles, the still-classified B-52, the record-shattering six-jet B-47, and other outstanding developments.

There are excellent opportunities, right now, for experienced and junior engineers for aircraft

• DESIGN • RESEARCH
• DEVELOPMENT • PRODUCTION
• TOOLING

also for servo-mechanism and electronics designers and analysts and for physicists and mathematicians with advanced degrees.

You can work in Seattle, in the Pacific Northwest, or in Wichita, Kansas. You will receive a generous moving and travel expense allowance. And as a Boeing engineer, you'll enjoy pay that is good and grows with you.

You'll be proud to say, "I'm a *Boeing* engineer!"

Write today to the address below, or use the convenient coupon.

JOHN C. SANDERS, Staff Engineer—Personnel
Dept. P-4
Boeing Airplane Company, Seattle 14, Wash.
Engineering opportunities at Boeing interest me. Please send me further information.

Name _____

Address _____

City and State _____

BOEING

SEND FOR FREE PRINT

From the Bettmann Archive

English steam automobile (ca.1820) stopping in front of the latest thing in fuel stations, with attendant offering coal at prevailing prices.

This is one of a series of old prints of old machines (and ways of power transmission) that will appear in future Morse advertisements. Write for your free, enlarged copy, suitable for framing for your collection.

M=TC

Morse *means* Timing Chains

Thirteen makes of today's passenger cars use timing chains. Of the thirteen makes, eleven use precision-built, dependable Morse Timing Chains as original equipment. It almost goes without saying that Morse is the leading producer of automotive timing chain drives. M=TC; Morse *means* Timing Chains.

MORSE CHAIN COMPANY

Dept. 311 • 7601 Central Avenue • Detroit 10, Michigan

MORSE

MECHANICAL

POWER TRANSMISSION

PRODUCTS

PRODUCTS OF BW BORG-WARNER

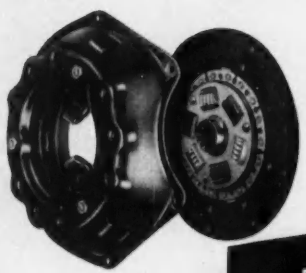
+ INDEX TO ADVERTISERS +

A. C. Spark Plug Div. General Motors Corp. ... 161
Aeroquip Corporation ... 185
Airesearch Division of The Garret Corp. ... 8, 9
Aluminum Company of America ... 150, 216, 217
American Bosch Corp. ... 211
American Chemical Paint Co. ... 103
American Felt Co. ... 224
Associated Spring Corp. ... 189
Barnes Co., Wallace (Div. Assoc. Spring Corp.) ... 189
Barnes Co., Wallace Ltd. (Div. Assoc. Spring Corp.) ... 189
Barnes-Gibson-Raymond Div. Assoc. Spring Corp. ... 189
Bearings Company of America ... 119
Bendix Aviation Corp.
Bendix Products Div. (Aviation Div.) ... 173
Bendix Products Div. ... 16
Stromberg-Elmira Div. ... 109
Zenith Carburetor Div. ... 152
Bendix Westinghouse Automotive Air Brake Co. ... 117
Bethlehem Steel Co. ... 172
Boeing Airplane Company ... 220
Bohn Aluminum & Brass Corp. ... 157

You can depend on —

BORG & BECK®

CLUTCHES... for that vital spot where power takes hold of the load!



Engineered by BORG & BECK means...

CLUTCHES EXPERTLY DESIGNED AND PRECISION BUILT BY CLUTCH-MAKING SPECIALISTS!

BORG & BECK CLUTCH · THE STANDARD ·

Reg. U.S. Pat. Off.

BORG & BECK DIVISION
BORG-WARNER CORPORATION
CHICAGO 38, ILLINOIS

Borg & Beck Div., Borg-Warner Corp. ... 222
Borg-Warner Corp. ... 121
Bound Brook Oil-Less Bearing Co. ... 167
Bower Roller Bearing Co. ... 182
Brush Development Co. ... 205
Bundy Tubing Co. ... 138, 139
Bunting Brass & Bronze Co. ... 196
Campbell, Wyant & Cannon Foundry Co. ... 107
C. A. V., Ltd. ... 104
Chicago Rawhide Mfg. Co. ... 190
Chiksan Company ... 169
Clark Equipment Co. ... 183, 184
Climax Molybdenum Company ... 106
Convair ... 150
Cummins Engine Co., Inc. ... 197
DeLuxe Products Corp. ... 120
Detroit Aluminum & Brass Corp. ... 202
Dietz Company, R. E. ... 175
Donaldson Co., Inc. ... 219
Douglas Aircraft Company, Inc. ... 204
Dow Corning Corp. ... 168
Dunbar Bros. Co. Div.—(Assoc. Spring Corp.) ... 189
Dynamatic Corporation Subsidiary of Eaton Mfg. Co. ... 203
Eagle Pencil Company ... 155
Eaton Mfg. Co., Dynamatic Div. ... 203
Eaton Mfg. Co., Foundry Div. ... 114
Eaton Mfg. Co., Saginaw Div. ... 113
Electric Auto-Lite Co. ... 111
Fafnir Bearing Co., The ... Inside Back Cover
Federal-Mogul Corp. ... 6
Felt Products Mfg. Co. ... 110
Fram Corporation ... 194
Fuller Mfg. Co. ... 143
General Plate Div. Metals & Controls Corp. ... 12
Gibson Co., Wm. D. (Div. Assoc. Spring Corp.) ... 189
Globe-Union, Inc. ... 179
Graton & Knight Company ... 199
Great Lakes Steel Corp. ... 207
Groov-Pin Corporation ... 116
Hagan Corporation ... 154
Hamilton Standard Division of United Aircraft Corp. ... 110
Hi-Shear Rivet Tool Co., The ... 106
Hyatt Bearings Div. General Motors Corp. ... 105
Imperial Brass Mfg. Co. ... 127
Imperial Pencil Tracing Cloth ... 150
Indiana Gear Works ... 214
International Nickel Co. ... 141
International Packings Corporation ... 199
Johnson Bronze Co. ... 144
Kelsey-Hayes Wheel Co. ... 215
Koppers Co., Inc. ... 145
Leece-Neville Co. ... 223
Libbey-Owens-Ford Glass Company ... 160
Lipe Rollway Corp. ... 136
Lisle Corp. ... 125
Lockheed Aircraft Corp. ... 201
Long Mfg. Div. Borg-Warner Corp. ... 162
Lycoming Spencer Division AVCO Mfg. Co. ... 180

+ INDEX TO ADVERTISERS +

McQuay-Norris Manufacturing Company ... 200
Marlin-Rockwell Corporation ... 164
Marvel-Schebler Products Div. Borg-Warner Corp. ... 135
MB Manufacturing Company, Inc., The ... 198
Mechanics Universal Joint Div. Borg-Warner Corp. ... 149
Micromatic Hone Corporation ... 177
Midland Steel Products Co. ... 126, 208
Milsco Mfg. Co. ... 219
Monowatt Department of General Electric Co. ... 171
Monroe Auto Equipment Co. ... 156
Moraine Products Div. General Motors Corp. ... 123
Morse Chain Co. ... 221
National Malleable & Steel Castings Co. ... 122
New Departure Div. General Motors Corp. ... 1
North American Aviation, Inc. ... 128, 129
O & S Bearing Co. ... 115
Ohio Div. Assoc. Spring Corp. ... 189
Palnut Company ... 118
Parker Rust Proof Co. ... 14
Perfect Circle Companies ... Inside Front Cover
Pesco Products Div. Borg-Warner Corp. ... 159
Pierce Governor Co., Inc. ... 131
Precision Rubber Products Corp. ... 3
Purolator Products, Inc. ... 142
Ramsey Corp. ... 137
Raymond Mfg. Co. (Div. Assoc. Spring Corp.) ... 189
Revere Copper & Brass, Inc. ... 11
Rochester Mfg. Co. ... 112
Rockford Clutch Div. Borg-Warner Corp. ... 132
Rohr Aircraft Corp. ... 174
Rollway Bearing Company ... 4
Ross Gear & Tool Co. ... 5
Saginaw Steering Gear Div. General Motors Corp. ... 153
Schrader's Son, A. ... 209
Sealed Power Corp. ... 176
Shore Instrument & Mfg. Co., Inc. ... 210
Sinclair Research Laboratories, Inc. ... 192, 193
SKF Industries, Inc. ... 140
Spencer Thermostat Div. Metals & Controls Corp. ... 178
Spicer Mfg. Div. of the Dana Corp. ... 165, 166
Standard Electric Time Company ... 186
Standard Locknut and Lockwasher, Inc. ... 170
Standard Steel Spring Co. ... 130
Sterling Aluminum Products, Inc. ... 7
Stewart-Warner Corp. ... 188
Stuart Oil Co., Ltd. D. A. ... 116
Superior Steel Corp. ... 195
Thompson Products, Inc., Detroit Div. ... 2
Thompson Products, Inc., Light Metals Div. ... 163
Thompson Products, Inc., Special Products Div. ... 151
Thomson Industries, Inc. ... 129
Timken-Detroit Axle Co. ... 147, 148
Timken Roller Bearing Co., Steel & Tube Div. ... Outside Back Cover
Torrington Co. (Needle Bearings) ... 187
Tung-Sol Electric, Inc. ... 134
Twin Disc Clutch Co. ... 124
United-Carr Fastener Corp. ... 146
Universal Products Co., Inc. ... 133
Vickers, Inc. ... 10
Victor Manufacturing & Gasket Co. ... 181
Wagner Electric Corp. ... 158
Waldes Kohinoor, Inc. ... 213
Wallace & Tiernan Products, Inc. ... 219
Waterman Products Co., Inc. ... 128
Wausau Motor Parts Company ... 206
Wellman Company, S. K., The ... 191
Yates-American Machine Co. ... 108
Young Radiator Co. ... 210

1952
ELECTRICAL DEMANDS
CALL FOR
Leece-Neville ALTERNATORS
Today's accessory load takes more current from the battery than conventional d.c. generators can put back in. Batteries fail . . . vehicles break down . . . costs mount.
For 1952 performance, replace out-dated d.c. generators with the Leece-Neville AC-DC Alternator System, that gives you
25 TO 35 AMPS WITH ENGINE IDLING
There are Alternators for 6 and 12 volt systems with capacities from 50 to 150 amps.
Write the Leece-Neville Company, Cleveland 14, Ohio. Distributors in principal cities Service Stations everywhere.
YOU CAN RELY ON
Leece-Neville
ALTERNATOR SYSTEMS • GENERATORS
STARTING MOTORS • REGULATORS • SWITCHES
FRACTIONAL HP MOTORS
TRUCK
BUS
DIESEL
OFF-HIGHWAY
PASSENGER
RAILROAD
MARINE
INDUSTRIAL

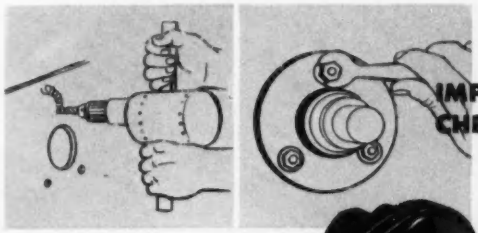
AMERICAN FELT FOR SEALS

American supplies special felts for seals. These are ideal materials for bearings, rotating shafts, housings, and similar applications. In many cases, such seals provide lubrication, and no attention is required between major overhauls. Lifetime sealing for ball bearings is another important application. For full information, write for Data Sheet No. 11, "Felt Seals, Their Design and Application." And remember, there are 15 other mechanical functions which felt can perform in your plant or product.

American Felt Company
TRADE MARK

GENERAL OFFICES: P. O. BOX 5, GLENVILLE, CONN.

SALES OFFICES: New York, Boston, Chicago, Detroit, Cleveland, Rochester, Philadelphia, St. Louis, Atlanta, Dallas, San Francisco, Los Angeles, Portland, Seattle, San Diego, Montreal.—PLANTS: Glenville, Conn.; Franklin, Mass.; Newburgh, N. Y.; Detroit, Mich.; Westerly, R. I.—ENGINEERING AND RESEARCH LABORATORIES: Glenville, Conn.



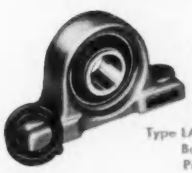
IMPROVEMENTS THAT COME CHEAPER BY THE PACKAGE

Fafnir economy packages

Fafnir Ready-to-Mount Flangette

Other typical Fafnir "packaged" ball bearing units

Type LAK Ball Bearing Pillow Block with Mechani-Seals



Type LAO (heavy duty) Ball Bearing Pillow Block

Type LCJ (light duty) Ball Bearing Flange Cartridge

Look again at the problem of shifting your farm equipment and machinery to ball bearings . . . with Fafnir Economy Packages in mind. These ready-to-mount units may represent advantages you never thought existed — the means of getting better assemblies with fewer parts at a saving in time and money. Farm equipment and machinery manufacturers are taking advantage of these Fafnir Economy Units to produce machines that run better, longer, with much less attention.

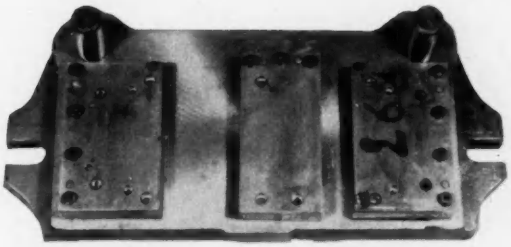
Fafnir Economy Packages provide not only ball bearings but also housings in shapes and sizes to fit an amazing variety of machines and equipment. In addition, they are available with various types of seals and shields and incorporate the famous Fafnir Wide Inner Ring Ball Bearing with Self-Locking Collar . . . easiest of all to install.

Whatever your product, a few minutes spent with a Fafnir representative may bring forth an Economy Package that opens the way to a major improvement at a minor expense. The Fafnir Bearing Company, New Britain, Conn.

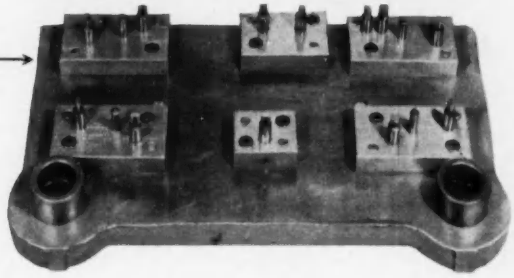
FAFNIR
BALL BEARINGS
MOST COMPLETE LINE IN AMERICA

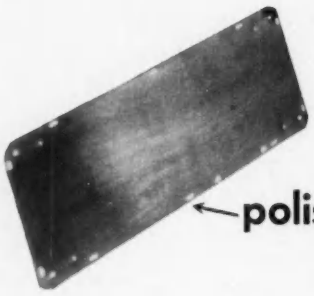
BUSINESS PRESS INC.
Lancaster, Pennsylvania

Die repairs eliminated →



punch life increased →





← polishing of stampings no longer needed

. . . with dies made of Graph-Mo steel

STAMPING out stainless steel parts for medical sterilizers was causing trouble for the Pelton & Crane Company, Detroit. The dies they were using—made of an ordinary tool steel—became worn after only a few hundred stampings. Holes in the parts were ragged, requiring polishing. The punches were continually chipping and cracking.

They then tried dies made of Graph-Mo—one of four Timken® graphitic tool steels. After 12,000 stampings, the Graph-Mo dies still showed no signs of wear. Stampings were clean and smooth. No polishing was needed. Pelton & Crane reports: "The fact that Graph-Mo stands up on stainless steel, where other types we used continually broke down, leads us to believe there is no finer tool steel on the market today than Graph-Mo."

Graph-Mo offers many advantages in dies and punches. Because of free graphite in its structure, Graph-Mo has minimum tendency to scuff or gall. Because it contains diamond-hard carbides, it offers unusual resistance to wear. Graph-Mo has excellent stability. Surfaces may be finished to precision tolerances. Machining is far easier than with ordinary tool steels. And Graph-Mo's uniform response to heat treatment prevents distortion in hardening.

For further information, write on your company letterhead for new, 10th edition of Timken Graphitic Steel Data Book. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphitic and standard tool analyses—and alloy and stainless seamless steel tubing.